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THE

PHILOSOPHICAL GRAMMAR;

Being a VIEW of the

PRESENT STATE

OF

EXPERIMENTED PHYSIOLOGY,

OR

NATURAL PHILOSOPHY.

In Four PARTS.

PART I. SOMATOLOGY, treateth of the univerſal Nature and Properties of Matter, or Subſtance, and the ſpecifick Qualities of natural Bodies.

PART II. COSMOLOGY, exhibiteth a general View of the Univerſe, and its great conſtituent Parts; the Sun, Moon, Planets, Comets, fix'd Stars, *&c.*

PART III. AEROLOGY, compriſeth the Philoſophy of the Atmoſphere, ſhewing the wonderful Nature and Properties of the Air, Wind, Meteors, and other Phænomena therein.

PART IV. GEOLOGY, containeth a philoſophical View of the terraqueous Globe, in all its Parts and Productions; as Minerals, Metals, Stones, *&c.* The Laws of Fluids; the Sea, its Tides, *&c.* Of Rivers, Springs, *&c.* Of Vegetation, and the Nature of Plants, Trees, *&c.* Of the Parts of animal Bodies; and a Survey of the Nature of Beaſts, Birds, Fiſhes, Inſects, Reptiles, Shell-Animals, *&c.*

The whole extracted from the Writings of the greateſt Naturaliſts of the laſt and preſent Age, treated in the familiar Way of Dialogue, adapted purpoſely to the Capacities of the Youth of both Sexes; and adorned and illuſtrated with Variety of Copper-Plates, Maps, *&c.* Several of which are entirely new, and all eaſy to be underſtood.

amin

By BENJ. MARTIN, Φιλότεχνος.

The Works of the Lord are great, ſought out of all them that have pleaſure therein, Pſalm cxi. 2.

Philoſophia mater omnium bonarum artium, nihil eſt aliud, niſi, ut Plato ait, donum et inventum Deorum. *Cicero*, 1 *Tuſc.*

LONDON:

Printed for J. NOON, at the *White-Hart* in *Cheapſide*, near *Mercers-Chapel.* MDCCXXXV.

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TO THE
BRITISH YOUTH
OF
BOTH SEXES,
THESE
RUDIMENTS, or Firſt PRINCIPLES
OF
NATURAL PHILOSOPHY

(Deſign'd for their

Rational DELIGHT and AMUSEMENT, and Real PROFIT and USE, in the IMPROVEMENT of their MINDS in the moſt Noble Part of KNOWLEDGE)

Are Humbly Recommended,

and Inſcribed by the Compoſer,

BENJ. MARTIN.

Hist of Science
Rogers
7-14-43
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10-T-44 BHP

THE PREFACE.

I Do not intend this Preface to give an Account of the Particulars contained in the following Book; the Title Page, large Table of Contents, or Running-Titles, are abundantly ſufficient for that: But rather that the Reader may have ſome Account of the Reaſons why I have compoſed for him the enſuing Treatiſe; and they are as follow:

Firſt, *The Knowledge of the wonderful Works of God in Nature, is of the moſt exalted and divine Sort, which human Underſtanding can pretend to; and the more we know of this, the more perfect will be our Nature, and the more nearly ſhall we approach to the Image and Likeneſs of God: And therefore, ſince this is the Subject of the Book before us, I think it ought to be made as plain, and as publick as poſſible, That all (who are not ſupinely ſunk beneath the Dignity of their Nature, and wretchedly content to live in Ignorance)* *may imbue their Minds with the Treaſures of Knowledge and Wiſdom, ſuch as will tend to make them wiſe to Salvation.*

Secondly, *Nothing (that I know of) has been compleatly and purpoſely handled in our own Language, on the Subject of Natural Philoſophy, ſo as to comprehend all its great Parts and Branches: Therefore I have undertaken it for their Sakes, who cannot read Books on this noble Subject in the learned Languages.*

Thirdly, *It is true, indeed, there are divers Pieces tranſlated from the* Latin, French, Dutch, *&c. Tongues into our own; but then, as they ſeem moſt or all of them originally deſigned for the Learned, ſo only Scholars are capable of underſtanding them as tranſlated, by Reaſon of the many bewildering mathematical Demonſtrations, and learned Diſquiſitions, which abound in moſt of them; and for which the young Student, and the fair Sex, are (generally) little the wiſer: Wherefore I judged it proper, for both their Sakes, that Something ſhould be done of this Kind, ſo plain, natural, and eaſy, as to be underſtood with Pleaſure; and yet, ſo general and copious, that nothing uſeful might be wanting.*

Fourthly, *The moſt famous Pieces of this Kind are, ſome of them, too expenſive for the Purſe of the Publick in general; as the Tranſactions of the Royal Society, Sir* Iſaac's Principia, *Dr.* Pemberton's *View thereof,* &c. *Some, or moſt of them, are filled with mathematical and ſymbolical Demonſtration, Schemes, Characters, that it ſurpriſes and repells the plain unlearned (or rather ungeometrical) Reader from any peruſal of them; who yet is capable of under-*

underſtanding a good Part of Philoſophy, when treated in a plain, evident and familiar Way.

Fifthly, *Many excellent Pieces on this Subject are very defective, and others as redundant, while others want Method, and are incoherent. Is it not ſtrange, that* Rohault's Phyſicks *ſhould ſay nothing of Vegetation, Trees, Plants,* &c. *the moſt important and obvious Part of Philoſophy? Where is the Order and Method of Mr.* John Clerck's Phyſicks? *And how ſtrong the Genius, which can ſupply by its Imagination, in almoſt every Part, the want of Cuts and proper Schemes? Sir* Iſaac's Principia *are all inveloped, not only from the common Ken, but from the general Tribe of Mathematicians themſelves. Dr.* Keil's *Introduction teaches little more, than the Philoſophy of Motion and Velocities. Mr.* Derham's *Phyſico-Theology gives you, in the Notes, a delightful View of Nature broke all to Pieces. If you are an unhappy* Atheiſt, *Mr.* Niewentyt's *Religious Philoſopher will either convince you at once, or ſtun you with a thouſand Tautologies. Dr.* Cheyne's *Philoſophical Principles, in one Part, have ſome noble Reflections on this Subject; and in the other, he has obliged you with a new diſcovered Source of Religion, in abſtruſe Reaſonings, and algebraick Theorems and Corollaries. The* Spectacle de la Nature *is but a partial Tract, and not intended for a Syſtem of Phyſiology. I ſhall take no Notice of any Compendiums and Epitomes, that are ſmaller than this I here preſent the Reader withal, well knowing the Limits I have confined the Subject to, are ſtrait and ſcanty enough.*

I ſhall now ſay Somewhat relating to the Order or Method, and Deſign of this Undertaking. And, Firſt, *I have here compoſed a general View of the modern State of Phyſiology, or natural Philoſophy, and treated of it in a moſt natural and grammatical Order: I begin with the general and ſpecial Properties and Qualities of Matter, and its various Modifications in natural Bodies: Then I conſider the great Parts of the Univerſe, the Sun, Planets, Comets, and Stars, which conſtitute the wondrous Frame: Next I deſcend to the Contemplation of the Atmoſphere proper to our Earth, and whatever is therein contained: Laſtly, I bring the Reader from the Regions above, to view the Wonders of Nature all around him in his Habitation here below, on this terraqueous Globe; and I cannot think of any Order and Method more conſentaneous to the Nature of Things than this.*

Secondly, *Whatever the Reader finds delivered as poſitive Doctrine and Aſſertions, he muſt know is all collected from the greateſt Authorities of the paſt and preſent Age, as* Lord Bacon, *Mr.* Boyle, *Sir* Iſaac Newton, *Dr.* Halley, Rohault, *Mr.* Samuel Clarke, John Clerck, Niewentyt, Cheyne, Whiſton, *Mr.* Derham, *Dr.* Keil, Gregory, Grew, Freind, Deſcartes, Graveſande, Boerhave, Goedart, Lemery, Bartholine, *and ſeveral others; who have all contributed more or leſs to the Piece in Hand.*

Thirdly, *All the great Points and Dogmata of the Science, here laid down and aſſerted, are ſuch as have been proved by Experiments and otherwiſe, by and in the Works of the learned Authors above-mentioned. I have here purpoſely diſcarded almoſt every Thing that depends on mere Hypotheſis or Conjecture;*

and have avoided all the tedious and fruitleſs Diſputations, and uncertain and endleſs Enquiries about them; which would have ſwoln the Book, and waſted the Reader's Time and Money to no Purpoſe.

Fourthly, *I have made many Things much more clear and eaſy to be underſtood, by exemplifying the ſeveral Caſes in Numbers, and thereby convey more obvious Ideas, than could be obtained by mere verbal Deſcriptions: Alſo I have contrived new, and more eaſy, plain and natural Schemes than are elſewhere to be found, for illuſtrating ſeveral important Matters, as Plate,* Fig. XXX. *for explaining the Seaſons of the Year,* &c. *In ſhort, I have omitted no Schemes that would make the Matter plainer, and be eaſily underſtood.*

Having thus given an Account why I have compiled the enſuing Tract, and of the Method and Deſign thereof; I ſhall now ſhew the Uſefulneſs of ſuch Kind of Contemplations and Studies as thoſe of natural Philoſophy; and that is two-fold, the firſt regards the Body, and the other the Mind of Man.

Firſt, *Natural Philoſophy conduces to the Health and well Being of the Body of Man; for which hear the admirable Author of the* 411th Spectator, *where he ſays,* " *We may here add, That the Pleaſures of the Fancy are more conducive to Health than thoſe of the Underſtanding, which are worked out by Dint of Thinking, and attended with too great and violent Labour of the Brain. Delightful Scenes, whether in Nature, Painting, or Poetry, have a kindly Influence on the Body, as well as the Mind; and not only ſerve to clear and brighten the Imagination, but are able to diſperſe*

“ *Grief and Melancholy, and to ſet the animal Spirits*
“ *in pleaſing and agreeable Motions: For this*
“ *Reaſon Sir* Francis Bacon, *in his Eſſay on*
“ *Health, diſſwades his Reader from knotty and*
“ *ſubtle Diſquiſitions, and adviſes him to purſue*
“ *Studies, that fill his Mind with ſplendid and illuſtrious*
“ *Objects, as Hiſtories, Fables, and the*
“ *Contemplations of Nature*”.

Again, *In* Spectator 393. “ *In the Opening*
“ *of the Spring, when all Nature begins to recover*
“ *her ſelf, the ſame animal Pleaſure, which makes*
“ *the Birds ſing, and the whole brute Creation rejoice,*
“ *riſes very ſenſibly in the Heart of Man.*
“ *I know none of the Poets who have obſerved ſo*
“ *well as* Milton, *thoſe ſecret Over-flowings of*
“ *Gladneſs, which diffuſe themſelves through the*
“ *Mind of the Beholder, on ſurveying the gay Scenes*
“ *of Nature; he deſcribes it very beautifully under*
“ *the Name of vernal Delight:*

“ Bloſſoms and Fruits at once of golden Hue
“ Appear'd, with gay enamel'd Colours mix'd;
“ On which the Sun more glad impreſs'd his Beams
“ Than in fair evening Cloud, or humid Bow,
“ When God hath ſhower'd the Earth. So lovely ſeem'd
“ That Landskip: And of pure, now purer Air
“ Meets his Approach, and to the Heart inſpires
“ Vernal Delight, and Joy able to drive
“ All Sadneſs but Deſpair”.

Again, *Natural Philoſophy fills the Mind with noble and exalted Notions, and regales it with the moſt agreeable Senſations: Thus the* Spectator *proceeds,* “ *The Creation is a perpetual Feaſt to the*

" Mind of a good Man, every Thing he ſees chears and delights him. Providence has imprinted ſo many Smiles on Nature, that it is impoſſible for a Mind, which is not ſunk in mere groſs and ſenſual Delights, to take a Survey of them without ſeveral ſecret Senſations of Pleaſure". Concerning this Matter you have, in Spectator 420th, *this elegant and ſublime Paragraph: " But amongſt this Set of Writers, there are none who more gratify and enlarge the Imagination than the Authors of the New Philoſophy; whether we conſider their Theories of the Earth or Heavens, the Diſcoveries they have made by Glaſſes, or any other of their Contemplations of Nature. We are not a little pleaſed to find every green Leaf ſwarm with Millions of Animals, inviſible, at their largeſt Growth, to the naked Eye. There is Something very engaging to the Fancy, as well as to our Reaſon, in the Treatiſes of Minerals, Metals, Plants, and Meteors. But, when we ſurvey the whole Earth at once, and the ſeveral Planets that lie within its Neighbourhood, we are filled with a pleaſing Aſtoniſhment to ſee ſo many Worlds hang one above another, and ſliding round their Axles in ſuch an amazing Pomp and Solemnity. If after this we contemplate thoſe wide Fields of Æther, which reach the Height from the Orb of Saturn to the fix'd Stars, and run abroad almoſt to Infinity, our Imagination finds its Capacity filled with ſo immenſe a Proſpect, and puts it ſelf on the Stretch to comprehend it. But if we yet riſe higher, and conſider the fix'd Stars as ſo many vaſt Oceans of Flame, that are each of them (as a Sun) attended with a different Set of Planets, and ſtill diſcover new Firmaments, and new Lights, that are ſunk farther in thoſe unfathom-*

“ *able Depths of Æther, as not to be ſeen with the* “ *ſtrongeſt of our Teleſcopes, we are loſt in ſuch a* “ *Labyrinth of Suns and Worlds, and confounded* “ *with the Immenſity and Magnificence of Nature*”.

Laſtly, *Another, and the greateſt Uſe of Natural Philoſophy is this, that it naturally inſpires us with religious and devout Diſpoſitions of Mind, awful and reverent Conceptions of the divine Author of Nature, and elevates us to the higheſt Pitch of the moſt rational Kind of Worſhip, and mental Adoration of him. On this Head hear again the noble Sentiments of the before-mentioned admirable Author of the* 393d Spectator: “ *Natural Philoſophy* “ (ſaith he) *quickens this* (*rational and delightful*) *Taſte of the Creation, and renders it not only* “ *pleaſing to the Imagination, but to the Underſtanding. It does not reſt in the Murmur of* “ *Brooks, and the Melody of Birds, in the Shade* “ *of Groves and Woods, or in the Embroidery of* “ *Fields and Meadows; but conſiders the ſeveral* “ *Ends of Providence which are ſerv'd by them,* “ *and the Wonders of divine Wiſdom which appear* “ *in them; it heightens the Pleaſures of the Eye,* “ *and raiſes ſuch a rational Admiration in the Soul,* “ *as is little inferior to Devotion. It is not in the* “ *Power of every one to offer up this Kind of* “ *Worſhip to the great Author of Nature, and to* “ *indulge theſe more refined Meditations of Heart,* “ *which are doubtleſs highly acceptable in his* “ *Sight*” —— Again, “ *The Chearfulneſs of* “ *Heart, which ſprings up in us from the Survey* “ *of Nature's Works, is an admirable Preparation for Gratitude. The Mind has gone a great* “ *Way towards Praiſe and Thankſgiving, that is* “ *fill'd with ſuch a ſecret Gladneſs: A grateful Re-*

“ *ſlection on the ſupreme Cauſe who produces it, ſanctifies it in the Soul, and gives it its proper Value: Such an habitual Diſpoſition of Mind conſecrates every Field and Wood, turns an ordinary Walk into a morning or evening Sacrifice; and will improve thoſe tranſient Gleams of Joy, which naturally brighten up, and refreſh the Soul on ſuch Occaſions, into an inviolable and perpetual State of Bliſs and Happineſs*”.

On all theſe important Accounts, it muſt certainly be looked upon as an indiſpenſible Duty of natural Religion to ſtudy and delight in natural Philoſophy; and is therefore incumbent on every Perſon, Male and Female, to employ their leiſure Hours, in ſome Meaſure, this Way. From hence it is alſo, that God himſelf ſo frequently calls upon us (in his Word) to meditate and conſider his wonderful Works, and the Operations of his Hands; and expreſſeth his Diſpleaſure againſt thoſe who ſupinely and brutiſhly neglect it.

Since then natural Philoſophy is of ſuch vaſt Importance to a Man's Health and Happineſs, I hope my Endeavours to make an Introduction thereto, general, plain, eaſy, and pleaſant, will be kindly accepted by all thoſe who are capable of the Impreſſions of Reaſon or Gratitude; and if ſo, it will be an Encouragement to do Something farther in this Way when Time ſhall permit.

I have only one Thing more to acquaint the Reader withal, and that is this: It may be thought ſtrange that I have taken no Notice of thoſe Syſtems of the World invented, or at leaſt maintained by Ptolemy, Tycho Brache, *and* Deſcartes, *which have made ſo much Noiſe in the learned philoſophick World: But as the firſt was too vulgar, the next entirely falſe,* *and the laſt monſtrouſly abſurd and contrary to all Experience, ſo they have been juſtly all exploded, and made to give Way to the more rational and true Syſtem, firſt advanced by* Pythagoras, *lately reviv'd by* Copernicus, *and at preſent eſtabliſhed as the Baſis of all true Aſtronomy and Philoſophy: An elegant View of which you have in* Figure XIX.

I thought it therefore unneceſſary to ſpend the Reader's Time about falſe and abſurd Trifles and Whimſies; it being entirely incompatible with my Purpoſe and Deſign, which was to gather together in one ſyſtematical View all the Notions, Doctrines, and great Diſcoveries in the Circle of natural Science, which are approved and known Truths, and ſuited to the Capacities of the Generality of People: And as ſuch I recommend the following Treatiſe; and ſhall conclude with wiſhing the Reader that Pleaſure and Profit in the peruſal thereof, which was deſigned him, and which naturally flows from thoſe delectable Topicks.

Chicheſter,
December 14, 1734.

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ADVERTISEMENT.

By the Author in *Chicheſter* are Taught,

I. WRiting, in all the common and uſeful Hands.
II. Arithmetick, of every Kind.
III. Algebra and Fluxions.
IV. Logarithms, with their Conſtruction and Uſe.
V. Geometry, in Theory and Practice.
VI. Trigonometry, both plain and ſpherical.
VII. Navigation, in every Kind.
VIII. Dialling in all its Parts.
IX. Aſtronomy and Geography.
X. Surveying of Land.
XI. Menſuration of plain Superficies and Solids.
XII. Gauging, in all the beſt Methods.
XIII. Mechanicks.
XIV. The Uſe of both the Globes.
XV. The Projection of the Sphere in Plano.
XVI. The Uſe and Conſtruction of all the moſt uſeful Mathematical Inſtruments.

The Theory and Practice of all the Mathematical Arts are very much expedited and facilitated by ocular Demonſtration, and actual Practice by the Learner himſelf; on very large Inſtruments, as Globes, Spheres, Sectors, Scales, Sliding-Rules, Maps, Charts, Diagrams, and other Contrivances for the Purpoſes of ſpherical Geometry and Trigonometry.

N. B. Youth are Boarded very reaſonably by the Author,
BENJAMIN MARTIN.

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The

THE

Philoſophical Grammar:

Or, VIEW of

Modern Philoſophy.

THE

INTRODUCTION;

CONTAINING

I. THE General Definitions of Philoſophy; the Subjects and Uſes of natural Philoſophy.

II. THE Parts and Subdiviſions thereof.

III. THE Axioms and Rules of Philoſophizing.

IV. OF Hypotheſes, Experiments, and Inſtruments for that Purpoſe.

CHAP. I.

Of the Science of Philoſophy in general; of natural Philoſophy in particular; its Parts and Subjects, and various Uſes in Life.

A. PRAY what is the genuine Meaning of the Word *Philoſophy?*

B. By Philoſophy, you are to underſtand the Science or Knowledge of the Nature, Cauſes, Properties, and Effects of all created Beings, ſo far as they are capable of being known by Reaſon, diſcovered by Art, or any Ways adapted to the humane Comprehenſion.

A. Pleaſe to be a little more particular in your Definitions, or I cannot ſo eaſily (as I would) apprehend you: What do you mean by the Nature of Things?

B. By the Nature of any Being, or Thing, is meant that peculiar State, or Condition, whereby it is differenc'd in its Kind from all other Beings whatſoever: Thus 'tis the Nature of God to be perfect; of Man to be ſociable; of Fire to be hot; of Ice to be cold, *&c.*

A. In like Manner explain what you mean by the Cauſes of Things, that I may the better apprehend you on theſe Philoſophical Subjects.

B. By natural Cauſes are to be underſtood the Means by which Things come at firſt to have their Being or Exiſtence: Thus God is the Cauſe of all created Beings, becauſe from him they firſt receiv'd their Being; and hence God is call'd by way of Preheminence the firſt and primary Cauſe of all Things.

A. I have heard, and alſo read of ſecondary Cauſes; pray what is the Reaſon of this Diſtinction?

B. I'll endeavour to inform you; ſecondary Cauſes are thoſe which produce their Effects according to the Direction and Influence of ſome eſtabliſhed and original Laws and Rules implanted in their Natures at their firſt Creation by God the primary Cauſe; of all other Cauſes he is the original Cauſe; and conſequently they, with Regard to the firſt Cauſe, can be only properly termed ſecondary Cauſes: So the Sun cauſeth Vapours; and Vapours cauſe Clouds; and Clouds condenſed cauſe Rain; Rain cauſeth Springs, Rivers, Vegetation, *&c.* But yet they all act in a ſecondary Manner under the original Influence of the firſt Cauſe, as aforeſaid.

A. Pleaſe next to define what you call the Properties of Bodies.

B. By Bodies, I ſuppoſe, you mean the ſeveral Kinds of Beings in general, as they appear to our Sight; and in this common Senſe of the Word, the Properties of Things are thoſe Qualities and Operations peculiar to themſelves, and which diſtinguiſh them from all other Kinds of Beings: Thus 'tis the Property of Man to laugh, and reaſon; of Glaſs to be tranſparent; of Air and Wind to be inviſible; of Space to be infinite; of God to do Good, *&c.*

A. The Knowledge of Effects you mentioned as a Part of Philoſophy; pray what am I to underſtand thereby?

B. This: That an Effect is whatever is produced or brought to paſs by the Action or Operation of any natural Cauſe: Thus Vapours are the Effect of the Sun's Attraction; Ice is the Effect of a cold Air; Light the Effect of luminous Bodies; and Purging and Vomiting the Effects of divers Herbs and Medicines.

A. Having given this general Account of Philoſophy, I ſhould be glad if you'd oblige me with a more particular one; pray how many Sorts of Philoſophy are there?

B. Philoſophy is divided generally into moral, and natural.

A. What do you call moral Philoſophy?

B. This is properly called *Ethicks*, from the *Greek* Word ἦθος, and *Morality* from the *Latin* Word *Mos*, plural *Mores*, both ſignifying *Manners* or *Behaviour*.

A. Pray what is the Buſineſs of moral Philoſophy?

B. To give Rules and Laws for the Behaviour, Manners, and Conduct of Man, as Man, or as a rational Creature.

A. Pleaſe to tell me the End or Deſign thereof.

B. The great End and Deſign of Morality is to make Mankind acquainted with the Means and Methods of being happy, or to obtain the greateſt Felicity in this Life.

A. Pray what do you properly call natural Philoſophy?

B. This hath two proper Appellations, one is *Phyſics*, from the *Greek* φυσις, *Nature*, or φυσικὴ, *Natural*; and ſo it imports to us the Science or Knowledge of Nature, or natural Bodies.

A. But you ſay it hath another Name; pray what is that?

B. Phyſiology; ſo called of φυσις, *Nature*, and λογος, a *Diſcourſe*; and by this is implied a Diſcourſe of Nature, and natural Bodies; and ſuch is the enſuing Book.

A. Since the Word *Philoſophy*, then, is general; what is implied by it?

B. The Word *Philoſophy* is compounded of the two *Greek* Words φιλία, *Love*, and σοφία, *Wiſdom*, or *Knowledge*; and thus it implies the Love of Wiſdom, or the Study of Knowledge or Learning in general, as aforeſaid.

A. How came the Word *Philoſophy* firſt in Uſe?

B. Pythagoras, a learned *Greek* Philoſopher of *Samos*, by his great Modeſty, eſteemed the Appellation σοφος, a *wiſe Man*, too arrogant (though the general Character of a learned Man before his Time) and therefore he was content to call himſelf φιλος, *a Lover*, σοφιας, *of Wiſdom*: And ſince him the Science has been called *Philoſophy*, i.e. *Love of Wiſdom*; and thoſe who ſtudy it, *Philoſophers*.

A. This is very Good, and pleaſeth me well; but pray, Sir, what is the proper Subject of natural Philoſophy?

B. Subſtance or Matter, under all the various Forms and Figures we behold it, which we call natural Bodies, with all their Properties and Affections.

A. What is the Deſign of natural Philoſophy?

B. To improve humane Knowledge, to make us better acquainted with Nature, to give us a rational Senſe of Things, by diſcovering the Reaſon of the various and different Affections, Qualities, and Effects of Objects, which offer themſelves to our Senſes, ſo far as is poſſible.

A. What are the more principal Uſes of Philoſophy in the Affairs of humane Life?

B. They are almoſt innumerable; for hereby Men are diſtinguiſhed from Brutes, who indeed behold the various Phaſes of Nature, but can tell the Reaſon or Cauſe of none; by this Art, the *Phyſician* acquires the Knowledge of the Virtue and Effects of Plants and Herbs; the *Chymiſt* hereby, obtains the Method of analyzing and diſſolving Mettals, Minerals, Plants, animal Subſtances, *&c.* and reducing them to their firſt Elements; the *Apothecary* hence, underſtands the Reaſon of the various Compoſitions of Simples for the making his Medicines; and the *Aſtronomer* hence, learns the Frame and Conſtitution of the Heavens, and the Magnitude, Diſtance and Phaſes of all the heavenly Bodies; the

Husbandman alſo, may know from the Rules of this Science, the moſt advantagious Methods of cultivating and manuring his Land; the *Navigator* from hence, borrows the Theory of his Art; and in ſhort, there is no State, Art, or Capacity, in Life, which does not directly, or indirectly, receive Advantage and Benefit therefrom.

CHAP. II.

Of the Parts and Subdiviſions of PHYSIOLOGY.

A. HOW many are the Parts of this Science of natural *Philoſophy?*

B. It may be properly divided into four general Parts.

A. Pray what are they?

B. Theſe which follow, *viz.*

I. *Somatology*, which treateth of the common Nature, Properties, and Qualities of Matter, and its various Combinations in natural Bodies.

II. *Coſmology*, or *Uranology*, which treats of the Nature, Conſtitution, and component Parts of the Univerſe in general, and particularly of our ſolar Syſtem.

III. *Aerology*, which treats of the Nature of the *Atmoſphere*, or Region of *Air*, and all the *Phænomena* thereto belonging

IV. *Geology*, which treats of the Nature, Make, Parts, and Productions of the Globe of Earth on which we live.

A. I ſuppoſe each of thoſe general Parts are yet farther to be ſubdivided, are they not?

B. Yes, into ſeveral other ſubordinate Branches.

A. Pray what are the Subdiviſions of the firſt general Part, *Somatology?*

B. Somatology, as it conſiders the common and ſpecial Properties of natural Bodies, is divided with Reſpect to them in the Manner I ſhall by and by name to you when we diſcourſe of that Part.

A. What are the particular Branches of the ſecond general Part?

B. Coſmology, or more properly *Uranology*, comprehends the following Branches, *viz.*

1. *Heliography*, which treats of the *Sun.*
2. *Selenography*, which treats of the *Moon.*
3. *Planetography*, which treats of the *Planets.*

4. *Cometography*, which treats of the *Comets.*

5. *Aſtrography*, which treats of the fix'd *Stars.*

A. Pray how is the third great Part ſubdivided?

B. *Aerology*, I divide as follows, *viz.* into,

1. *Aerography*, which treats of the *Atmoſphere*, or Body of *Air*.

2. *Anemography*, which treats of the *Winds.*

3. *Meteorography*, which treats of the *Meteors.*

4. *Phantaſmatography*, which treats of the *celeſtial Appearances*, or ſuch *Phænomena*, as exiſt only in Viſion, and not Corporally.

A. How do you ſubdivide the laſt general Part?

B. *Geology*, is moſt naturally divided into the following ſubordinate Branches, *viz.*

1. *Geography*, which treats of the *Earth*, or *Land.*

2. *Hydrography*, which treats of *Water.*

3. *Phytography*, which treats of *Plants* and *Vegetables*.

4. *Zoography*, which treats of *Animals* of all Kinds.

And thus you have a conciſe View of the ſeveral Parts or Subjects of our enſuing *Colloquies.*

A. Sir, Nothing will ſo enamour my intellectual Senſes, as Reflections and Contemplations on ſuch Topics as theſe; I always love to hear People talk of the Wonders of Nature, and being now directly engaged in a Converſation purely on thoſe delectable Topics, my Appetite is whet, and my Deſires excited almoſt beyond Saturity.

B. I'll do my Endeavour to ſatisfy you if poſſible, and am very glad to find you hunger and thirſt after uſeful Knowledge; while others vainly ſpend their precious and irrevocable Time in idle and profane Amuſements, you have the Happineſs of ſuperior Senſe to dictate to you the more noble, manlike, and virtuous Methods of improving your Time; which will yield you not only abundance of Delight, and rational Pleaſure, but at the ſame Time make you Wiſe and Happy: To this End, I ſhall communicate to you whatever I have found in the Writings of the great *Sages* and *Virtuoſoes* of the laſt and preſent improving and inquiſitive Age, and will endeavour to make all Things plain and eaſy, as I go along, by familiar Inſtances, and evidently demonſtrative Figures and Schemes.

CHAP. III.

Of AXIOMS *relating to* PHYSICS; *of the* RULES *of* PHILOSOPHIZING.

A. ARE there not ſome fundamental *Principles*, or *Axioms*, on which this Science depends?

B. Yes, moſt certainly; the chiefeſt of which I ſhall here lay down.

A. Pray what do you make the firſt *Axiom*?

B. Axiom I. Nothing hath no Properties.

A. Pleaſe to exemplify this *Axiom*.

B. I will; but firſt underſtand, that by Nothing, is meant a State of Non-Exiſtence, or Not-Being; and therefore to ſay Nothing is hot, is cold, hath Parts, is Great, or Small, &c. would be abſurd.

A. What is the ſecond *Axiom*?

B. *Axiom* II. Somewhat doth exiſt.

A. That's ſomewhat merry, *Sir*, I believe No-body will deny that to be an *Axiom*, indeed.

B. You may think of it as you pleaſe; but, I aſſure you, I have met with thoſe who have had recourſe to *Logic*, to prove their own Exiſtence.

A. Pray let me know your third *Axiom*.

B. *Axiom* III. There is no Medium between Something and Nothing, Exiſtence and Non-Exiſtence.

A. This is moſt certainly true, and to ſuppoſe the contrary were abſurd; pray let me know your fourth *Axiom*?

B. *Axiom* IV. That which doth exiſt, and is independent on any other created Being for its Exiſtence, is properly the Eſſence or Subſtance of the Thing exiſting. The Truth of this, though infinitely evident to thoſe, who have been uſed to a philoſophical Way of Thinking, will, perhaps, appear more clear to you farther on.

A. Pray let me hear your next *Axiom*?

B. *Axiom* V. No Subſtance, or Eſſence, can be produced out of Nothing; or 'tis impoſſible Nothing ſhould be made Something.

A. This indeed is very true; for if Nothing could be made Something, it would then have ſome Property, which is contrary to your firſt *Axiom*; and conſequently abſurd. I pray, your ſixth *Axiom*?

B. Axiom VI. No Matter, Subſtance, or Eſſence of any Thing, is capable of being reduced to mere Nothing, or annihilated.

A. True likewiſe; for if Something could be converted into Nothing, then would Nothing have a Property, contrary to *Axiom* I. Alſo, as 'tis impoſſible for a Thing to be, and not to be, in the ſame Moment; therefore between the Time of its Being, and Not-being, there muſt be ſome intermediate State of Exiſtence, contrary to *Axiom* III. Pleaſe to relate your next *Axiom.*

B. Axiom VII. Every Effect hath ſome Cauſe.

A. That I, and every Body elſe, muſt believe, elſe nothing in Nature would be wonderful. Pray deliver your next *Axiom.*

B. Axiom VIII. If we our ſelves are not the Cauſe of any Effect, then that Effect muſt depend on, and reſult from, ſome other Cauſe.

A. This is a plain Conſequence of the foregoing; your next *Axiom* if you pleaſe.

B. *Axiom* IX. All Things, as far as in them is, continue in the ſame State in which they began their Being.

A. I believe I take you right, you mean what was at firſt made Strait, Crooked, Square, Round, *&c.* would of themſelves always perſevere in that State, and of their own Accord would never aſſume any other Figure.

B. Very good; that is the full Meaning of the *Axiom.*

A. Pray let me hear your next?

B. *Axiom* X. Every Change is produced from ſome external Cauſe.

A. Moſt certainly; for ſuppoſe I ſee a Flower in full Bloom lie withered on the Ground, I preſently conclude ſome external Cauſe hath made that Change in the Flower; which elſe would have continued vivid and freſh.

B. That's the Caſe; I have one *Axiom* more to propoſe, and that is, *Axiom* XI. That every Change made in any Body, is always proportionable to the Powers of the Cauſe producing it. Thus the Motion of a Body is always in Proportion to the Greatneſs of the Power, or Stroke, that put it firſt into Motion.

A. And are there no other Maxims of this Science, that are neceſſary to be diſcourſed of before we go farther?

B. No: Thoſe already related are ſufficient for this Place; but as this Science depends on certain Principles, ſo it is likewiſe to be conducted by certain ſtated *Rules.*

A. I doubt not but this Part of Knowledge, which (according to the Notion I have of it) is very abſtruſe and difficult in many Parts, muſt require proper *Rules* and *Precepts* for a due Improvement, as well as moſt other Arts. Pray, *Sir*, then, What and how many are the *Rules* of *Philoſophizing?*

B. They are in Number few, and are as follow, *viz.*

Rule I. We muſt take Care to admit no more Cauſes of natural Things than what are true, and ſufficient to explain their *Phænomena.*

Rule II. We muſt obſerve always to aſſign the ſame Cauſes for the ſame natural Effects.

Rule III. Thoſe Qualities which cannot be increaſed, or diminiſhed, and agree to all Bodies in which Experiments can be made, muſt be adjudged the Properties of all Bodies in general.

Rule IV. Propoſitions and Concluſions, deduced from actual Experiments, muſt be eſteemed true and accurate, notwithſtanding any *Hypotheſes*, or received *Suppoſitions*, to the contrary; and muſt be inſiſted on 'till ſome other *Phænomena*, either render them more accurate, or liable to Exception.

A. Pray what is the Reaſon of the firſt *Rule?*

B. It is founded on this Principle: Nature doth nothing in vain; but it is in vain to do that by many Means which may be done by fewer: Now Nature is ſimple, and never luxuriates in ſuperfluous Cauſes of Things. Therefore, &*c.*

A. That's exceeding good, indeed. Pray illuſtrate the ſecond *Rule*.

B. By the ſecond *Rule*, we are to aſſign the ſame Cauſes of Reſpiration in Beaſts, as in Men; of Heat in Water, as in Fire; of Light in Fire, as in the Sun; and of the Reflection of Light in the Planets, as in the Earth, &*c.*

A. Pray give the Reaſons of the third *Rule*.

B. The Qualities and Properties are not known to us but by Experiments; and therefore whatever we find to anſwer by all Experiments we can try, muſt be allowed a univerſal Property of all Bodies; of thoſe on whom we cannot, as well as of thoſe on whom we can, make Experiments: Nature being always conſentaneous and analogous to it ſelf.

A. Indeed the Reaſon of the laſt *Rule* is ſo obvious, that, I think, none can doubt it, no Perſon being ſo perverſe and prepoſterous, as to affirm there is more Reaſon in a bare *Hypotheſis*, than in *Facts* of *Experiment.*

B. Yet, 'tis ſtrange, you'll ſay, that, by this very *Rule*, the Syſtem of the *Carteſian Philoſophy* muſt fall; that *Burnet*'s Theory of the *World* and *Deluge*, muſt be valued at no greater Eſtimation than an ingenious *Romance:* And thus muſt Mr. *Whiſton*'s, and all other *World-Mongers* Syſtems and Theories, diſſolve into a philoſophical Nothing, which want actual and repeated Experiments to ſupport them.

CHAP. IV.

Of Hypotheſes, of Experiments, of various Inſtruments for that Purpoſe, and their Uſes.

A. ARE any Kinds of Hypotheſes to be admitted in reaſoning about natural Subjects?

B. The Philoſophers of the preſent Age hold them in vile Eſteem, and will hardly admit the Name in their Writings; they think that which depends on bare Hypotheſes and Conjecture, unworthy the Name of Philoſophy; and therefore have framed new and more effectual Methods for philoſophical Enquiries.

A. And muſt therefore a Philoſopher in no wiſe have recourſe to Suppoſitions? May he not be admitted to ſay, he ſuppoſeth a Thing may be ſo, or ſo? Or muſt he immediately aſſign an experimented Cauſe, or elſe directly confeſs his Ignorance? What are your Thoughts in this Matter?

B. Why I muſt confeſs, to diſcard all Hypotheſes from *Phyſics*, is to reduce it within very narrow Limits; and in Truth, I think, 'tis falling from one Extreme to another; I am perſwaded that Hypotheſes duly qualified, if not abſolutely neceſſary, yet may be very ſubſervient to natural Philoſophy; and I know not what Kind of Philoſophers we ſhall have in ſucceeding Ages, if they will receive no Syſtem of Philoſophy, but what is wholly founded on mathematical Experiments and Demonſtrations.

A. Pray what Kind of Hypotheſes, and how qualified, do you allow may be uſed in *Philoſophy?*

B. They muſt have moſt or all the following Qualifications.

1. They muſt be agreeable to juſt Reaſoning.
2. They muſt be neceſſary, for want of Experience.
3. They muſt be conſentaneous to Experience.
4. They muſt be ſufficient to ſatisfy the *Phænomena*.
5. They muſt be naturally adapted to the Caſe.
6. They muſt be poſſible on every Account.

7. They muſt be probable in their own Nature.

8. They muſt be free from all Suſpicion of Prejudice, Affection, or Prepoſſeſſion, in their Author.

A. I believe, *Sir*, few will deny you the Uſe of Hypotheſes thus circumſtanced and qualified: But pray, what Kind of Demonſtrations are thoſe by Experiments, which you intimate they rely ſo much upon?

B. The very beſt of all Nature can produce; they far exceed the keeneſt Glance of the Eye of Reaſon, and nothing but divine Revelation can inform us more truly of the intimate Natures of Things.

A. Very wonderful indeed! Happy the Age in which this Art receiv'd Improvements from ſuch extraordinary Inventions. Pray who were the firſt Authors of improving *Philoſophy* by Experiments?

B. Their Names are recorded in the Book of Fame; have you not ſeen therein the glaring Characters of *Bacon*, *Boyle*, Sir *Iſaac Newton*, *Woodward*, Dr. *Halley*, *Ray*, *Derham*, and ſeveral other exalted *Virtuoſo's*? Some of which are now living; and others ſubſiſt in marble Monuments to gratify the Curioſity of, and be admired by all Poſterity.

A. Yes, I have heard of thoſe great Names you mention'd, but not being very converſant in the learned World, know but little about them; yet, take an exceſſive Pleaſure in hearing Relations of them, and the wonderful Things they have diſcover'd.

B. I am glad to find in you ſuch a Diſpoſition, and queſtion not but you will be highly gratified with the Series and Sequel of our Diſcourſe.

A. I believe I ſhall; but to the Point, in what Manner, I pray you, are thoſe Experiments perform'd? for, as you have ſeen the Manner thereof, you can well inform me.

B. They who have reduced experimental Philoſophy to Method, and make it their Buſineſs to teach it others, prepare a large *Apparatus* of Inſtruments of all Kinds, to the Value of five or ſix hundred Pounds; and at ſtated Times, in a very large Room, there is an Operator appointed to perform a Courſe of Experiments therewith, in all the various Parts of natural Philoſophy, in the open View of all who are preſent to ſee and learn the Manner thereof.

A. Cannot you give me ſome particular Account of thoſe Inſtruments, and the Manner of uſing them?

B. It is the Subject of a large Volume to deſcribe them with their Uſes in particular: However of ſuch as are moſt common, to be had in the eaſieſt Manner, and which you your ſelf may underſtand, and uſe if you pleaſe, you may take the following Account:

The *Teleſcope*, is an optic Inſtrument, wherewith to view diſtant Objects, which it greatly enlargeth, and makes them ſeem near us; by which Means the Aſtronomers and Philoſophers have made wonderous Diſcoveries in the Sun, Moon, and Planets.

The *Microſcope*, is contriv'd to augment and render viſible very minute and ſmall Objects, which otherwiſe eſcape the Sight.

The *Helioſcope*, is a Sort of *Teleſcope*, fitted ſo, as to look on the Body of the Sun without Offence to the Eyes.

The *Barometer*, or *Baroſcope*, is contriv'd to eſtimate the ſmall Variations of the Weight or Preſſure of the Air.

The *Anemoſcope*, is a Machine, invented to foreſhew the Change of the Air, or Wind.

The *Aeolipile*, is contriv'd to ſhew the Nature and Force of pent up Air, rarified and breaking forth, reſembling a Tempeſt, &c.

The *Aerometer*, is an Inſtrument to meaſure the ſpecific Gravity of Liquids.

The *Hygrometer*, is an Inſtrument to meaſure the Moiſture and Dryneſs of the Air.

The *Hygroſcope*, ſheweth the Increaſe and Decreaſe of the Dryneſs of the Air.

The *Thermometer*, meaſureth the Heat and Cold of the Air.

The *Thermoſcope*, only ſheweth the Increaſe and Decreaſe thereof.

The *Hydroſtatic* Ballance, is an exceeding exact fine Pair of Scales for making Experiments, relating to the Gravity of Fluids.

Dioptrick Inſtruments of various Sorts to explain the Nature of refracted Rays of Light, through various Mediums.

Catoptrick Inſtruments are alſo manifold, which ſhew the Nature of reflected Rays of Light.

The *Pneumatick* Engine, called the *Air-Pump*, is the moſt univerſal of all others; it's the very Baſis of the Philoſophy of the Air, and hath opened a greater Door to the Secrets of Nature, than any Thing that was ever invented beſides; and it were endleſs to ſpeak of this in particular, and all the other Inſtruments in general, that are invented to explain and confirm the other Parts of *Phyſiology*.

A. Surely wonderful Curious and Delightful muſt it then be to ſee all thoſe extraordinary Things performed by ſuch nice Inſtruments! Alas! what inert, ignorant, and narrow Souls have we poor *Mechanics* and *Plebeians*; what wretched, unworthy, and uncouth Notions have we conceiv'd of the World, and Things therein! We think our ſelves learned, if we know how to find out a Word in *Bailey*'s Dictionary, little dreaming ſo much Pains, Expence, and Time, neceſſary to acquire but a partial Knowledge, and to be eſteemed but moderately learned!

B. Well, but don't be diſcouraged; the Knowledge of theſe Things will be much eaſier and cheaper to us, than they were to our Forefathers; what coſt them Pounds, we may have for ſo many Pence; what coſt them Years of Study, Fatigue, and Diſquietude, we may acquire with Eaſe and Pleaſure in a few Days or Months; what they rejoyced to come at by Piece-meals, and in an imperfect Manner, we have preſented, as in one intire methodical View. Wherefore if we are Ignorant, 'tis becauſe we are idle and indolent indeed: If we live ſatisfied only with the vulgar erroneous Notions of fallacious Senſe, and endeavour not to rectify them by the Precepts of refined and learned Reaſon, and the Methods put into our Power; in vain then, hath God given us Ability to be *wiſer than the Fowls of Heaven, and to have more Underſtanding than the Beaſts which periſh.*

THE

Philoſophical Grammar:

Or, VIEW of

Modern Philoſophy.

PART I.

SOMATOLOGY:

OR,

DOCTRINE of the univerſal Properties of MATTER; and the ſpecific Qualities of natural BODIES; with *Sir* ISAAC NEWTON's Laws of Nature.

CHAP. I.

SOMATOLOGY, *treating of the common Nature and Properties of all natural Bodies.*

A. WHAT do you call *Somatology?*

B. That Part of *Phyſiology*, which treateth of Matter or Subſtance in general, with the Nature and inſeparable Properties of all Bodies conſiſting thereof.

A. What is implied in the Original of the Word *Somatology?*

B. The very ſame Thing; for it is compoſed of the two *Greek* Words, Σωματα, *Bodies*, and λογος, *a Diſcourſe*; i. e. *a Diſcourſe of natural Bodies.*

A. What do you mean by Matter?

B. The Subſtance, or Eſſence, of which all Things in the Univerſe doth conſiſt.

A. Is there any Difference between what you call Matter, and Body?

B. No; excepting only, that the latter is uſed often in the Plural for the ſeveral ſmall Parts and Diviſions of the common Subſtance of the Univerſe; *i. e.* they are called Bodies.

A. Is the intimate Nature of Matter to be known?

B. No; this is conceal'd from humane Knowledge; all we can diſcover of natural Bodies, are ſome few Properties and Affections thereof, which are more obvious to our Senſes.

A. Is the original Matter of all Bodies the ſame?

B. Yes; what the Philoſophers call the primary conſtituent Particles, Atoms, or Corpuſcles of Matter, which conſtitute Bodies of infinite Kinds, are yet the ſame, or of the ſame Nature, among themſelves, in all thoſe Bodies.

A. And what, is not this the ſame Thing as to ſay, that Fire and Water, a Flint and Down, Gold and Dung, *&c.* are the ſame Things with reſpect to the Matter it ſelf of which they conſiſt?

B. Yes, they are ſo; and what then, my Friend?

A. What then, why then, I believe, you will have few Diſciples amongſt the common People; and ſeveral will think they give it a better Term than it deſerves, if they call ſuch Aſſertions *philoſophical Romancing.*

B. 'Tis very probable, it may be ſo; but the real Nature and unchangeable Truth of Things, are ſtill to be inſiſted on, tho' they are unknown to, and gain no Credit with the Vulgar.

A. Is Matter finite, or infinite?

B. Finite; and limited within certain Spaces and Bounds in the various Parts of the Univerſe.

A. Do you think Matter is created, or eternal?

B. Naturally, it is impoſſible for it to exiſt from Nothing, by *Axiom* V. But whether abſolute Nothing, under the Management of omnipotent Power, is capable of being wrought into Exiſtence, or Subſtance, without overturning, by wholeſale, the Foundations of all Philoſophy, I ſhall not here determine; nor yet, whether there be any Thing of Blaſphemy in aſſerting it to be eternal; only this, I think, at preſent, that according to the ſtricteſt *Rules* and *Axioms* of *Philoſophy*, it muſt be ſo.

A. How is Matter, or Body, commonly conſider'd?

B. As having three Dimenſions, *viz.* Length, Breadth, and Thickneſs.

A. Is this Conſideration of Matter the moſt philoſophical?

B. No; 'tis too vulgar and defective.

A. What is a more accurate Method to acquire the beſt Knowledge and Ideas of Matter, or Bodies, that we are capable of?

B. By conſidering thoſe Properties and Affections thereof, which are obvious to us, and beſt known by us.

A. How are the Properties of Bodies diſtinguiſhed?

B. Into thoſe which are common to all alike, and thoſe which are peculiar to each in particular: The firſt are called Common and Eſſential, the latter Specific and Accidental.

A. Which are the Properties of the firſt Sort?

B. They are generally reckoned theſe which follow:

I. *Extenſion*, for all Bodies are extended.

II. *Diviſibility*, for all Bodies may be divided.

III. *Solidity*, for the Particles of all Bodies are hard.

IV. *Figurability*, for all Bodies have ſome Form or Figure.

V. *Mobility*, for all Bodies are capable of being moved.

A. Is this Enumeration of the common Properties of Bodies every way juſt, and equal in all Things?

B. No, I do not think it is; for firſt, they may all be aſſerted of the whole Body except *Solidity*, which agrees only to the Particles of Bodies; again, other Properties may as univerſally be aſſerted of Bodies as ſome of theſe, as *Durability*; for a Body is no leſs infinitely durable, than it is infinitely diviſible.

A. Which are thoſe other Properties of Bodies, which you call *Specific* or *Accidental*?

B. They are generally reckoned the following:

I. *Light.*
II. *Colours.*
III. *Sound.*
IV. *Gravity* and *Levity.*
V. *Attraction* and *Electricity.*
VI. *Tranſparency* and *Opacity.*
VII. *Denſity* and *Rarity.*
VIII. *Hardneſs* and *Softneſs.*
IX. *Rigidity* and *Flexibility.*
X. *Conſiſtence* and *Fluidity.*
XI. *Heat* and *Cold.*

XII. *Humidity* and *Siccity.*
XIII. *Elaſticity.*
XIV. *Odours* and *Sapours.*

A. What do you call the Elements of natural Bodies?

B. Thoſe pure and ſimple Subſtances of which all groſs and mix'd Bodies are ſaid to conſiſt; and into which they may ultimately be reſolv'd, or reduc'd.

A. How many are thoſe Elements reckoned to be?

B. The Ancients counted ſeven, *viz. Fire, Air, Water, Earth, Salt, Sulphur, Mercury.*

A. How many do the Moderns reckon?

B. Some of the modern chymical Philoſophers reckon five, *viz. Mercury, Phlegm, Sulphur, Salt,* and *Earth.* Others reduce them to three, *viz. Mercury, Sulphur,* and *Salt.* Whereas in reality, there are no other Elements of natural Bodies than the primogenial Particles of Matter, or Subſtance, of which they conſiſt univerſally, and endued with the Properties above mentioned.

CHAP. II.

Of Extenſion, and the Magnitude, and Dimenſions of natural BODIES.

A. I Remember you ſaid the firſt of the univerſal and eſſential Properties of Matter, or Body, was *Extenſion*; pray explain what is meant thereby?

B. Extenſion of *Matter*, is the Quantity of Bulk, or Size, into which the primogenial Particles of Matter are diſtributed, or extended, in any natural Body.

A. What ariſeth hence?

B. The Doctrine of Magnitude, and Dimenſion of Bodies.

A. Pray, what do you call the Magnitude of Bodies?

B. Their Size, or Bulk, or Quantity of Space, which they take up.

A. How do you compute, or eſtimate, the Magnitude of Bodies?

B. By the Quantity of their Dimenſions.

A. What do you call the Dimenſions of Bodies?

B. Their Extenſion in Length, Breadth, and Thickneſs, or Depth; and theſe are the common Terms, or Bounds, which limit the Subſtance of all Bodies.

A. Have all Bodies theſe three Dimenſions?

B. Yes, they have; though one, or two, or all of them, eſcape our Senſes; yet, they nevertheleſs exiſt together in all Bodies.

A. How do ſome then ſay, that a Point hath no Dimenſions?

B. They mean by this, a Point, or the ſmalleſt Part of Space, which, naturally ſpeaking, is Nothing, and therefore hath no Properties.

A. How are Bodies differenc'd with Reſpect to their Dimenſions?

B. They are by Mathematicians, on that Account, diſtinguiſhed into *Points*, *Lines*, *Superficies*, and *Solids*.

A. As how?

B. They call that a *Point*, when all the three Dimenſions are ſo very ſmall, as to be altogether imperceptible, as the Speck A: A *Line*, is that which appears to have no Breadth, or Thickneſs, as BC: A *Superficies*, that which hath Length and Breadth, but no perceiveable Thickneſs, as ABCD: *Laſtly*, they call that a *Solid*, which hath evidently all the three Dimenſions, as the

Solid S; whoſe Length, is AC, its Breadth, AB, and its Thickneſs, or Depth, AE. See *Fig.* 1, 2, 3 *and* 4. *Plate* 1.

A. How many are the Degrees of Magnitude?

B. They are infinite; for no Body however great or ſmall can be given, but another may be conceiv'd greater or ſmaller than it; as I ſhall demonſtrate to you when we diſcourſe of the Diviſibility of Matter.

A. How are Bodies, or Things, ſaid to be great or ſmall?

B. Greatneſs, or Smallneſs, are only relative Terms; and Things are great or ſmall only as they are compared one with another: Thus a Mountain two or three Miles high, is a great one, and one not above two or three Perches high, is a ſmall one, when they are compared together.

A. Then, I ſuppoſe, you count it improper and unphiloſophical, to ſay any Thing is abſolutely great or ſmall.

B. Moſt certainly it is; becauſe the ſame Thing is either great or ſmall by Compariſon only: Thus a Hog is a ſmall Creature, compared with the largeſt Elephant; but it is a great Creature, when compared with a Louſe that crawls on his Back.

CHAP. III.

Of the Diviſibility of Matter, of the Infinity thereof, and of the wonderful Ductility and Diviſibility of ſeveral BODIES.

A. PRAY what is the Diviſibility of Matter?

B. It is that univerſal Property or Diſpoſition of a Body, whereby it is capable of being divided or reduced into Parts, either actually or mentally.

A. How far are Bodies capable of being divided?

B. Body is diviſible in *infinitum*, or without end.

A. This is a wonderful Doctrine! What will you ſay, that the leaſt Grain of Sand is capable of being divided into Parts ſtill leſſer and leſſer, through all the Ages of Eternity?

B. Yes; and as wonderful as it is, it is capable of no leſs than a plain mathematical Demonſtration.

A. Do you ſay ſo! I wiſh it may be ſuch as I can underſtand; pray let me ſee it however.

B. I will, and I'll engage that you or any one may underſtand it; and it is thus, let EF (*Fig.* 5. *Plate* 1.) be a right Line, I ſay that Line may be divided into a Number of Parts exceeding any finite Number, and it is thus demonſtrated: Through E and F, the two Extremities of the Line, let there be drawn the two parallel Lines AB, CD, and ſuppoſe they were infinitely extended to the right Hand; then 'tis evident, that in the Line CD, infinitely extended, there may be taken an infinite Number of Points, a, b, c, d, e, *&c.* Now if to each of thoſe Points, there be drawn ſtrait Lines from the Point A (taken in AB, to the left of the given Line EF) each of thoſe Lines Aa, Ab, Ac, *&c.* will cut off a ſmall Portion of the Line EF; but becauſe the Points a, b, c, *&c.* are infinite in Number, ſo likewiſe are the Lines Aa, Ab, Ac, *&c.* and conſequently the Parts, or ſmall Portions, they will cut off of the Line EF, will be infinite in Number alſo; and thus it is manifeſt, that the Line EF, however ſmall, may yet be divided into an infinite Number of Parts.

A. Indeed 'tis ſo plain, that I muſt confeſs and believe it: Pray what may we infer from this wonderful Property of Matter?

B. Firſt, That the leaſt Particle of Matter is capable of an infinite Diviſion, as well as the greateſt.

Secondly, That there is no ſuch Thing as infinitely ſmall Particles of Matter.

Thirdly, That the original or primogenial Particles of Matter, into which it may be ultimately reduced, are altogether paſt humane Comprehenſion.

Fourthly, Hence we learn what wonderous Effects a ſmall Piece of Matter may produce by its Diviſibility and Ductility.

A. Pray what do you call the Ductility of Matter?

B. That Diſpoſition of it, whereby it is eaſily drawn out into Length, or Breadth.

A. What curious and extraordinary Inſtances have you of this Kind?

B. I think the following very remarkable, *viz.*

Mr. *Boyle* ſaith a Piece of Silk, weighing $2\frac{1}{2}$ Grains only, was drawn out into a Thread three hundred Yards long.

He ſaith alſo, that one Grain of Gold may be beat into a Leaf of fifty ſquare Inches.

If then an Inch in Length be divided into two hundred Parts, the Eye may diſtinguiſh them all; wherefore in one Grain of Gold are 2000000 of viſible Parts.

An Ounce of Silver may be gilt with eight Grains of Gold, which afterwards may be drawn out into a Wire of 1300 Foot long.

Dr. *Halley* has made it appear, that 124500 of thoſe very fine Skins of Gold, uſed in gilding Silver-wire, do not in Thickneſs exceed an Inch. Beſides ſeveral other Inſtances.

A. Theſe Things are very admirable indeed; what other remarkable Diſcoveries have iſſued from the Diviſibility of Matter?

B. The extraordinary Subtility of Matter, and the Tenuity or Fineneſs of its Parts, will appear by theſe Inſtances.

Mr. *Boyle* hath found that one Grain of Copper will tincture 28534 Grains of Water; and therefore in a Drop of Water, whoſe Diameter is one hundredth of an Inch, there are contained 2114000 viſible Parts of Copper, reckoning only an 100 to an Inch.

Again, Dr. *Keil* hath computed the Magnitude of a Particle of *Aſſa Fœtida*, to be $\frac{38}{1000000000000000000}$ Parts of a Cubick Inch.

He has likewiſe ſhewn that one of thoſe Globules of Blood, which circulate in the Veins of ſome very ſmall Creatures, doth not exceed the $\frac{8}{1000000000000000000000000000000000000}$ Part of a Cubic Inch.

Once more, he hath alſo demonſtrated that one Grain of Sand will contain 125000000000000000000000000 of the aforeſaid Blood-Globules; that is 10256 Times more than the higheſt Mountain upon Earth contains Grains of Sand.

Laſtly, He hath ſhewn the leaſt Particle of Matter ſhall be made to fill the greateſt Space (ſuppoſe the Orb of *Saturn*) ſo that there ſhall be no Pore therein, whoſe Diameter ſhall exceed the 1000000000000th, *&c.* of an Inch.

CHAP.

CHAP. IV.

Of the Solidity and Figurability of BODIES.

A. WHAT is that common Property of Matter, or Body, which you call *Solidity?*

B. Solidity is that Property, whereby a Body reſiſteth all others that preſs it on every Side, and whereby it hinders all other Bodies from entring into that Place which it poſſeſſeth, though they are forced againſt it ever ſo violently.

A. Then ſuppoſe I preſs a Body ever ſo forcibly between my Hands, that Property which prevents my Hands from coming to a mutual Contact, you call *Solidity*, if I underſtand you right.

B. Yes, I do ſo; and this Property is the Ground or Cauſe of all Reſiſtance in Bodies.

A. Is not this a new Term for this Property?

B. Yes, it hath been formerly called *Impenetrability*; that is, whereby two Bodies cannot penetrate each other, or be in the ſame Place at once.

A. And is the Exchange of *Impenetrability* for *Solidity*, made on good Grounds do you think?

B. A great Man made it, and a greater hath approved it; but under Favour of them, I think the Word Reſiſtance, expreſſeth this Property much better than either of the other.

A. I pray your Reaſons for that?

B. *Impenetrability* is a Negative, and therefore not ſo proper; *Solidity* is ambiguous, for thereby we often expreſs the Hardneſs of Matter; a Property entirely different from what is here intended by it. The Word Reſiſtance expreſſeth the Thing aſſerted by each of thoſe Names; and therefore (being neither improper nor ambiguous) is more fit than either of them.

A. And is this Property of Matter the ſame in liquid or fluid Bodies, as it is in hard or fix'd ones?

B. The very ſame; for a Drop of Water, or a Particle of Air, remaining fix'd between any two Bodies, will no leſs hinder their Contact, than an equal Quantity of Steel or Diamond would do.

A. Pray what is that you call Figurability of Body or Matter?

B. That univerſal Diſpoſition thereof, whereby 'tis neceſſitated to appear in, or put on ſome Sort of Shape, or Figure, or other.

A. Wherein doth the Shape or Figure of Matter conſiſt?

B. In the Manner, or Mode, or Faſhion, of its Extremities, or external Superficies, within which it is contained.

A. Is it not the ſame with what is call'd the Form and Modification of Matter?

B. Yes; and ſince the Forms of Matter are only the Shape, or Faſhion, of its terminating Extremities, we muſt exclude ſubſtantial Forms, as the contradictious Nonſenſe and Jargon of the Schools.

A. Doth this Property of Matter you now diſcourſe of, equally relate to the original primogenial Particles of Matter, as well as to the groſſer Compoſition thereof in natural Bodies?

B. Yes; but in thoſe inconceiveable Particles of Matter, the Forms, no doubt, are much more ſimple, regular, and determinate, than in thoſe heterogeneous Compoſitions which we are acquainted withal.

CHAP.

CHAP. V.

Of Mobility of Matter, and the Nature of Motion and Reſt.

A. PRAY what is meant by the Mobility of Matter?

B. It is that eſſential Property, whereby any Part of Matter is capable of Motion, or being moved.

A. What is Motion?

B. A continual and ſucceſſive Change of Place.

A. What is Reſt?

B. The Continuance of a Body in the ſame Place, for any Time.

A. What is the Cauſe of Motion?

B. An external Force or Power applied to any Body; which being ſuperior to its Reſiſtance, impelleth or driveth it out of its Place.

A. How is Motion diſtinguiſhed?

B. Into abſolute and relative.

A. What is abſolute Motion?

B. The real Motion of a Body, from one Part of abſolute Space to another.

A. What do you call relative Motion?

B. It is the Change of Place with reſpect to ſome other Things at reſt: And abſolute and relative Reſt is juſt the contrary to theſe.

A. What do you obſerve hence?

B. That a Perſon may relatively be at Reſt, who yet is really and truly in abſolute Motion.

A. Pleaſe to exemplify this Matter.

B. I will: Suppoſe a Perſon ſeated in a Ship, he appeareth to all within the Ship to be at Reſt; though at the ſame Time he is moved with the ſame Motion, with the ſame Swiftneſs, and according to the ſame Courſe, as the Ship it ſelf is, with regard to abſolute Space.

A. What are the general Affections of Motion?

B. They are theſe three, *viz.*

1. The *Celerity* or *Velocity* of *Motion.*
2. The *Quantity* of *Motion.*
3. The *Direction* of *Motion.*

A. Pray what do you mean by the *Celerity* of *Motion?*

B. It is that whereby a Body paſſeth over a given Space, in a given Time: So that if in one Minute a Body A paſſeth over the Space ab, and another Body B paſſeth over the Space cd, in the ſame Time; then the

Celerity or *Swiftneſs* of the Body A will be to the *Celerity* of the Body B, as the Line ab is to the Line cd. See *Fig.* VI.

A. How do you compute the *Quantity* of *Motion?*

B. By compounding the Proportion of the Quantity of Matter, and the Velocity of Motion: Thus, if the Body A hath two Parts of Matter, and ſix Degrees of Velocity, the Motion of that Body will be twelve. See *Fig.* VII.

A. Then by this Means I perceive you have an eaſy Method of comparing the Quantity of Motion in any two or more Bodies.

B. Yes, very truly: For, ſuppoſe the Body A hath two Parts of Matter, and ſix Degrees of Velocity; and the Body B hath four Parts of Matter, and ten Degrees of Velocity; then the Quantity of Motion in A, paſſing from a to b, will be to the Quantity of Motion in B, paſſing the Space cd, as twelve to forty. See *Fig.* VII.

A. Why then I find, that if the Quantity of Matter in any two Bodies be equal, and their Velocities unequal, and the contrary, their Quantity of Motion will likewiſe be unequal.

B. It will ſo; for the Quantity of Motion in two Bodies will never be equal, if their Matter or Velocity differs, unleſs in this one Caſe, when the Quantities of

Matter and Velocity are in reciprocal Proportion to each other: As thus, 4 : 2 :: 6 : 3. Wherefore the Motion of B, with three Degrees of Velocity, is equal to the Motion of A, with ſix Degrees thereof. See *Fig.* VII.

A. What do you call the Direction of Motion?

B. It is a right Line, ſuppoſed to be drawn towards the Place where the moving Body tends: As ab is the Direction of the Body A, in *Fig.* VI.

A. What other Diviſions of Motion do you make?

B. Why, according to the Force impreſſed on Bodies, their Motion is either ſimple or compound.

A. Pray, *Sir*, what is ſimple Motion?

B. When only one Force or Power acts on any Body, the Motion produced thereby is ſimple, and according to the Direction of the impreſſed Force.

A. And, next, pleaſe to explain compound Motion.

B. This is produced when two or more Forces act on any Body in different Directions: Thus, ſuppoſe a Power H act on the Body A, with eight Degrees of Force, in the Direction ab; and another Power I act on it with ſix Degrees of Force, in the Direction ac; I ſay, the Motion of A, is not ſimply in either of the Directions ab or ac, but in a Direction compounded of both; *viz.* ad, and that with ten Degrees of Force; and arrives to d in the ſame Time as it would have arrived to b or c with thoſe Forces ſingly. See *Fig.* VIII.

CHAP. VI.

Of LIGHT.

B. HAving thus taken a brief Survey of the moſt general and eſſential Properties of Matter; let us now proceed to thoſe which are more particular, called the ſpecific or accidental Qualities of Bodies.

A. By all means, *Sir*, proceed; for 'tis a Converſation of ſo noble a Sort, that I ſhall never recompenſe the Time and Trouble you take to inſtruct me: But, to continue the Thread, pray, why are they called ſpecific or accidental Qualities?

B. They are called Specific, becauſe thereby the ſeveral Kinds of Bodies have their Diſtinction, and are what they are, and are differenced from one another: Thus, *Fire* by *Heat*, *Glaſs* by *Tranſparency*, *Liquors* by *Fluidity*, *Solids* by their *Fixity*, &c. are diſtinguiſhed from each other; and are accounted particular Species of Being or Matter.

A. But you do not ſay why they are termed Accidental.

B. I was juſt going to tell you; they are thus called, becauſe they are not eſſential to Matter, but happen to part thereof *per Accidens*, or by *Caſualty*; for 'tis purely ſo, that one Part of Matter is diſpoſed to be *hot*, another *cold*, another *dry*, another *light*, another of this *Colour*, and another of that.

A. Which of thoſe Qualities will you pleaſe to begin withal?

B. *Light*; this being the moſt conſiderable and wonderful of all others; and by which, all Things are made viſible and known.

A. Pray what do you call *Light*?

B. That Quality of certain Bodies, whereby they become viſible to us, and render others ſo.

A. What is the true Cauſe of *Light* in thoſe Bodies?

B. No Man can certainly tell; however, ſome affirm it to conſiſt in the extreme vibrating Motions of the Parts of thoſe luminous Bodies.

A. By what Means doth *Light* come to affect our Eyes?

B. 'Tis ſuppoſed this is owing to a very fine ætherial Matter, vaſtly rarer than Air, which is the Medium by which the Rays of thoſe luminous Particles are tranſmitted or propagated to our Eyes, and illuminate them with their *Light*.

A. You then ſuppoſe, I find, that what we call Rays of *Light* are real Bodies, or Particles of Matter, endued with the Quality of *Light*, and not the Quality it ſelf.

B. You hit it; I do indeed not only ſuppoſe it, but am ſure of it.

A. Are you indeed! then I am ſure not only my ſelf, but Thouſands more, have been long miſtaken. Pray, is not the Sun the Fountain of *Light* originally?

B. No: He is only the greateſt Body that emits *Light* in our *planetary Syſtem*; *Light* it ſelf being a Quality innate to thoſe Bodies, which emit it naturally.

A. But why do you ſay naturally?

B. Becauſe opake Bodies, when heated beyond a certain Degree, will emit *Light*; and all Bodies, eſpecially ſulphureous ones, having their Parts ſufficiently agitated do ſhine or emit *Light*: Whether this be by Percuſſion, as *Quick-ſilver*, when ſhaken in *Vacuo*; or by Attrition, as a *Cat's* Back, or *Horſe's* Body, &c. rubbed in the Dark; or by Putrefaction, as happens in *Wood*, *Fleſh*, &c. when putrified; or by any other Way.

A. Is the Motion of *Light* inſtantaneous or ſucceſſive?

B. It being found (by Obſervation) that *Light* is ſucceſſive, or propagated in Time, hath at Length ended this long and difficult Controverſy.

A. By what kind of Obſervations is this diſcover'd?

B. Aſtronomical Obſervations; the Principal of which is, that of the *Eclipſes* of the *Satellites* of *Jupiter*; for thoſe *Eclipſes*, when the Earth is between the *Sun* and *Jupiter*, happen ſeven or eight Minutes too ſoon; and when the Earth is beyond the *Sun*, they happen as much later than they ſhould by the *Tables*; the Reaſon of which is, that *Light* hath farther to go in the latter Caſe than in the former, by the Diameter of the Earth's annual *Orbit*.

A. Why, if this be the Caſe, you may nearly compute the Motion of *Light*; can you not?

B. Yes, eaſily, could we tell preciſely the Diſtance of the *Sun*: Some make it 10000, and others 20000 Diameters of the Earth; let us then take the Mean 15000, and it is well known the Diameter of the Earth is about 7935.475 *Engliſh* Miles; therefore the Diameter of the Earth's Orb is 119032125 Miles: Hence at the Rate of 7½ Minutes, or 450 Seconds in paſſing from the *Sun*, *Light* will be found to fly 264516 Miles in a Second of Time.

A. Pray make this incredible Swiftneſs of *Light* a little more intelligible by Example.

B. I will: 'Tis found that a Bullet, at his firſt Diſcharge from the Muzzle of a Cannon, flies one Mile in a little above 8½ Seconds, and therefore would be 32¼ Years in arriving to the *Sun*; hence the Proportion of Swiftneſs in a *Cannon-Ball* and *Light*, is as 1 to 3112 nearly; that is, *Light* flies three thouſand one hundred and twelve Times faſter than a Bullet at his firſt Diſcharge.

A. Wonderful are the Works of God! Not only paſt finding out, but paſt Belief when but imperfectly known! But, pray, what other Properties of *Light* are diſcovered?

B. *Light* is not only found to be a Body, but it is alſo found to conſiſt of Rays tinctured with all the original Colours in Nature.

A. In what Order are the Rays of *Light* found to be coloured?

B. According to the different Degrees of Refrangibility in the Rays: From Rays leſs Refrangible to thoſe that are moſt ſo, the Colours appear in this Order, *viz. Red, Orange, Yellow, Green, Blue, Indigo,* deep *Violet:* But more of Colours when we diſcourſe directly thereof by and by.

A. Pray what other Affections of *Light* are obſervable?

B. Its Reflexibility and Refrangibility.

A. What do you call the Reflexibility of *Light*?

B. The Diſpoſition of the Rays to be reflected, or turned back from the Surface of any Bodies on which they fall: Thus the Ray aB falling on the Surface AC, in the Point B, is reflected or turned back again in the Direction Bd. See *Fig.* IX.

A. In what Manner or Order is this?

B. The Law of Reflection of *Light* is invariable; for the Angle aBc, of the incident Ray aB, is ever equal to the Angle cBd, of the reflected Ray Bd, and the Perpendicular cB. See *Fig.* IX.

A. Pray what do you mean by the Refrangibility of *Light*?

B. The Diſpoſition of the Rays of *Light* to be refracted, or broken out of their direct Courſe, in paſſing through one tranſparent Body or Medium into another: Thus the Ray aB, paſſing through the Medium of Air to B, and there ſtriking on the Surface of Water AC, is refracted or broken out of its direct Courſe BE, into another BF, towards the Perpendicular BG. See *Fig.* X.

A. Doth the Refrangibility of Rays alſo obſerve any ſtated Law or Order?

B. Yes: For the Line HI, of the Angle of Incidence CBH, is always in the ſame Proportion to the Line MF=IK, of the Angle of Refraction GBF; as 4 to 3 in *Water*; and as 17 to 11 in *Glaſs:* That is, HI:MF :: 4:3 in *Water*; and HI:MF :: 17:11 in *Glaſs.* See *Fig.* X.

A. What may we learn by this Doctrine of the Reflection of *Light?*

B. The Reaſon why Objects appear juſt as far behind any *Plane Speculum*, or *Looking-glaſs*, as they really are before it, and the ſame Way: Thus, ſuppoſe AC the Section of a *Looking-Glaſs*, 'tis plain any Object placed before it at *a*, as the *Arrow*, will appear juſt ſo far behind the *Glaſs* AB as E, and directed to the ſame Point in the *Glaſs* B: For all Objects appear in that Ray Ed, that meets the Eye in d, be it any how reflected or refracted. See *Fig.* IX.

A. And are our Eyes thus deceived by the Refraction of *Light?*

B. Beyond your Imagination, I believe.

A. Aye, indeed! Pray oblige me with an Example how and in what Reſpects.

B. I will; and that by a very vulgar Experiment: Suppoſe AGHB be a *Veſſel*, whoſe Length GH is 56 Inches; let any Object, as a half Crown, be placed exactly in the Middle thereof at F; then let the *Veſſel* be filled with Water to the Height CD, 24 Inches; let FP be a Ray of *Light* paſſing from the Object F to P, but there meeting with the Air, is refracted towards N, and becomes PN. Now 'tis evident an Eye placed in N, cannot, by any Means, ſee the Object F (for the Sight is interrupted by the Side of the *Veſſel* at e) before the Water is poured into the *Veſſel*; after it is poured in, the Eye at N will indeed ſee the Object F, yet not in its true Place at F, but in another, diſtant 15¼ Inches at E; alſo to an Eye placed perpendicular over the Object F, it will appear to be in O, and the whole Bottom of the *Veſſel* will ſeem elevated to IK, the Height of FO, 11 Inches. See *Fig*. XI.

A. Well, 'tis very wonderful, as well as diverting and improving, to ſee and conſider of thoſe Things: I could not, indeed, have thought that Things placed ſo far out of Sight could thus be made viſible; and that we ſhould behold them in Places ſo far diſtant and different from the true: Well, 'tis well we have Reaſon to guide us, for I perceive our moſt exquiſite Senſes are fallible, and often deceiv'd.

B. 'Tis true, our Senſes are liable to Deception, and 'tis well for us in many Caſes they are; for as I go on, I ſhall often ſhew you the Advantages which accrue to us thereby, and from the Cauſes thereof; particularly the Reflection and Refraction of *Light*.

A. Pray how came Bodies firſt of all to be endued with this wonderful Property of *Light?*

B. By the omnipotent *Fiat* of the great Creator; he ſaid, יהי אור, *Sit Lux,* let there be *Light*, and immediately there was *Light*; and the ſtupendous Body of the Sun was created, as it were a *Repoſitory* or *Store-Houſe* thereof, whence it was to be diſtributed to every Part of the *planetary Syſtem*, in order to make the Whole viſible, and uſeful to the various Inhabitants thereof.

A. Can you give any Account of the Smallneſs of the Particles of *Light?*

B. Yes: It is computed, that in a Second of a Minute, there flies out of a burning Candle, the following Number of Particles of *Light*, 418660000000000000000000000000000000000000000000000000, which is 10000000000, or ten Millions of Millions Times a bigger Number than 10000000000000000000000000000000000, the Number of the Grains of Sand, computed to be contained in the whole Earth.

CHAP.

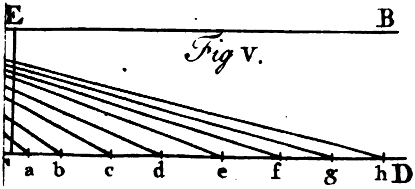
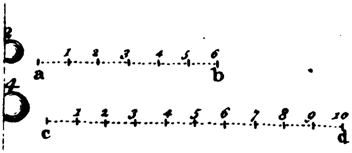


Fig V.



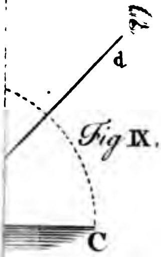


Fig IX.

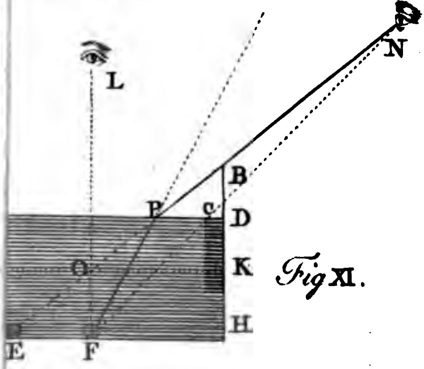


Fig XI.

Em: Bowen Sculp.t

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CHAP. VII.

Of the COLOURS *of* LIGHT; *and natural* BODIES.

A. NOW if you pleaſe, *Sir*, let us turn our Diſcourſe to the *Phænomena* of *Colour*: And firſt, be pleaſed to define what *Colour* is?

B. Colour is that Quality of Bodies, whereby they are diſpoſed ſo to modify and reflect the Light falling on them, and ſtriking on the Organ of Sight, as thereby to occaſion or produce the Senſation of *Colour* in our Minds: And that Senſation in us, is alſo call'd *Colour*.

A. Whence is the original of *Colours?*

B. All the *Colouring* in the Univerſe proceeds originally from the *Rays of Light*; for in them are contained all the primary, original, and abſolutely pure and unmixed *Colours*.

A. Which, and how many, are thoſe primary and original *Colours?*

B. Thoſe which follow: 1 *Red*, 2 *Orange*, 3 *Yellow*, 4 *Green*, 5 *Blue*, 6 *Indigo*, 7 *Violet*.

A. How are thoſe *Colours* diſcerned and diſtinguiſhed in the *Rays of Light?*

B. By Means of the different Degrees of its Refrangibility; for thoſe Rays which are leaſt refrangible, are tinctured with Red, and paint that *Colour* on Bodies; and thoſe which are moſt refrangible, are violet Purple, and paint Bodies therewith; and the intermediate Degrees of refrangible Rays, are dyed with the intermediate *Colours*, in the Order as before-mentioned.

A. By what Experiment do you prove this Doctrine?

B. By this eaſy one following: In a Chamber made dark, make an oblong Hole in the Window-Shutter at F, about $\frac{1}{8}$ of an Inch in Breadth; through which will enter the Sun Beam FH, and a large Priſm ABC, placed at about 20 Feet from the Hole, will refract the Rays of this Beam; after which they will again unite and become a white Beam at H, where let be applied an opake Body GHI, at the Diſtance of 2 or 3 Feet from the Priſm, in which let there be an oblong Hole made at H, $\frac{1}{40}$ or $\frac{1}{60}$ of an Inch in Breadth, through which the white Part of the Beam being tranſmitted, and made to fall on a Piece of white Paper placed after, will there paint the primitive original *Colours of Light*; ſuppoſe *Red* at t, *Yellow* at s, *Green* at r, *Blue* at q, and *Violet* at P. See *Fig*. XII.

A. Well, very good, and what is the Conſequence of all this, *Sir?*

B. Why then with a Piece of Wire R (or any opake Thing about $\frac{1}{10}$ of an Inch thick) you may, by intercepting the Rays at k, l, m, n, o, take away any one of the *Colours* at t, s, r, q, or P, whilſt the other *Colours* remain as before.

A. What do we learn by this Experiment?

B. *Firſt*, That the *Rays of Light* paint natural Bodies with different *Colours*: *Secondly*, That the leaſt refrangible Rays, as t, paint *Red*; and the moſt refrangible ones, as P, paint the deepeſt *Violet Purple*; and that other intermediate refrangible Rays paint the other intermediate *Colours*: *Thirdly*, That thoſe Differences of *Colour* are abſolutely and really exiſting in the *Rays of Light*, and do not ariſe from the different Confines of Shadow, variouſly modifying the *Light*, as has hitherto been the Opinions of Philoſophers.

A. I think it ſeems from hence, as if you would inſinuate, that *Colours* are not *connate* with Bodies, or naturally in them, but painted on them by the *Rays of Light*.

B. 'Tis very true: *Colours* only are in the *Rays of Light*, not in Bodies; and all Bodies are of the ſame Hue in the Dark, and appear differently *colour'd* only by, and in the *Light*.

A. Strange Doctrine this! I am apt to think you'll perſwade very few that *Colours* are not in Bodies, when they conſtantly ſee all around them tinged with ſuch an agreeable Variety.

B. If they will not be convinced by Reaſon and Experience, they muſt remain Ignorant, and ſtill poſſeſs their Prejudices and Errors.

A. But according to this Notion of *Colours*, how comes it to paſs that ſome Bodies are all of one *Colour*, ſome all of another, and ſome of ſo many different *Colours*?

B. This is eaſily conceived; for the Matter of ſome Bodies univerſally reflect one Sort of Rays more copiouſly than another; and according to the Refrangibility of thoſe Rays are the Bodies *colour'd*: Thus *Minium* reflects the leaſt refrangible Rays moſt copiouſly, and thence appears *Red*; *Violets* reflect the moſt refrangible Rays, and thence have their *Colour*; and ſo of their intermediate Degrees: Again, the Matter of ſome Bodies is ſuch as reflects different refrangible Rays; and therefore is in various Parts of various *Colours*.

A. Pray, *Sir*, what can be the Meaning that *White* and *Black* are not reckon'd among the *primary Colours* of *Light*?

B. Becauſe *White* is ſo far from being a pure, ſimple, original *Colour*, that, on the contrary, 'tis a Mixture of all thoſe 7 original *Colours* together; or a Compoſition of *Colours*,

Colours, even all the *Colours* in Nature: And on the other Hand, *Black* is properly no *Colour* at all, being only the Hue of thoſe Bodies, whoſe Subſtance abſorbeth all the *Rays of Light*, and therefore by reflecting none, cannot, of Conſequence, be *colour'd* at all.

A. Then thoſe Bodies which appear *White*, I apprehend, are ſo by reflecting promiſcuouſly all the *Rays of Light* which fall on them.

B. Yes, they are ſo. I have one Thing more very curious on this Head of *Colours* to relate to you, and then, if you pleaſe, we will make a Tranſition to another Subject.

A. Pray what is that? I long to know, being raviſhed with theſe Kinds of natural Curioſities.

B. It is this: Sir *Iſaac Newton*, by Experiments, hath found that the *Colours of Light*, with reſpect to their Quantity, were in Proportion to the *ſeven muſical Notes*, or *Intervals of Sound*, contained in an *Octave*, viz. *Sol*, *la*, *fa*, *Sol*, *la*, *mi*, *fa*, *Sol*. See *Fig*. XIII.

A. Bleſs my Stars! a Diſcovery indeed! ſure the happieſt Man alive for Experiment! What! Muſic and Harmony in *Colours!*

B. Yes, he diſcovered it thus: He cauſed a Sun Beam to be largely refracted on the

Side of a dark Chamber, which produced the *Spectrum of Colours*, repreſented by ABCDEF; in which he cauſed an Aſſiſtant exactly to mark the Confines of each *Colour*, by drawing parallel Lines betwixt each, as am, bi, ck, *&c.* and thus the Spaces V, I, B, G, Y, O, R, repreſents the Quantity of the reſpective *Colours*, viz. *Violet*, *Indigo*, *Blue*, *Green*, *Yellow*, *Orange*, *and Red*: And upon a nice Examination, he found the parallel Sides of the *Spectrum* AF and CD, to be divided in the Points a, b, c, d, *&c.* juſt in the Proportion as a muſical Chord is divided for the Concords of an *Octave*, viz. as the Intervals of theſe Numbers, 1. $\frac{8}{9}$. $\frac{5}{6}$. $\frac{3}{4}$. $\frac{2}{3}$. $\frac{3}{5}$. $\frac{9}{16}$. $\frac{1}{2}$.

A. This would induce one to think there were ſome Kind of Relation between *Muſic and Colours*; ſince it hence appears, that in Nature, they are adjuſted in the ſame Proportion, and both deſigned to delight and pleaſe Mankind, and ſooth the Cares of Life.

B. One Thing more I muſt remind you of, and that is this: Some Perſons tell us *Colours* are tangible Qualities, and may be diſtinguiſhed by *Feeling*, and give an Inſtance of one that could and did do it: But this is certainly impoſſible to do naturally; and therefore if any one ever did do it, he muſt have a miraculous *Gift of Feeling*.

CHAP.

CHAP. VIII.

Of SOUND.

B. LET us next entertain our ſelves with a Conſideration of the Nature and Property of *Sound*; for this is no barren Part of Nature, nor a uſeleſs Speculation, the Curious know.

A. Come on then, *Sir*, If you are not tired, I never ſhall with theſe noble Diſquiſitions and Enquires; and pray tell me firſt wherein *Sound* doth conſiſt?

B. *Sound* is the undulatory Motion of the Air, ariſing from the tremulous Motion of the Parts of any Body occaſioned by a Stroke; and thoſe Undulations or Pulſes of the Air beating on the Tympanum, or Drum of our Ears, convey, by the Nerves, this Senſation to our Minds.

A. How doth it happen that one and the ſame *Sound* may be heard by ſo many at once, and in different Places?

B. Becauſe the Vibrations and Tremors of the Air, excited by the Percuſſion of any Body, are propagated in concentric Spheres all around the ſaid Body (which is their common Center) to very great Diſtances; and therefore let a Perſon be any how, or any where ſituated within the Verge of thoſe Motions, he will equally hear the *Sound*, at equal Diſtances from the Body whence it comes: See *Fig.* XIV. where DD repreſents a Drum, and D. 1, 2, 3, 4, 5, *&c.* the circulating Motion of the Air made by, and conveying the *Sound* of the Beats to our Ears.

A. How is it to be proved, that Air is thus the Medium of *Sound?*

B. By the Experiment of a Bell in the Receiver in an *Air-Pump*, which, before the Air is exhauſted, may be heard to a conſiderable Diſtance; but when exhauſted, can ſcarcely be heard at the neareſt Diſtance.

A. What Velocity of Motion hath *Sound?*

B. Very great, but not ſo great by near as that of *Light:* Mr. *Derham* has found by Experiment that the mean *Velocity of Sounds* is at the Rate of 1142 Feet in one Second of Time, or a Mile in 4½ Seconds; and therefore would take up 17½ Years in paſſing from the Earth to the Sun, which is near double the Velocity of a Bullet at his firſt Diſcharge from the Cannon.

A. Can you certainly tell, *Sir*, how far *Sounds* may be heard?

B. Indeed, *Sir*, this is a Matter not altogether certain; but there are Reports of *Sounds* (as the Exploſions of great Guns, *&c.*)

&c.) which have been heard to the Diſtance of 180 or 200 Miles.

A. Doth not the Wind greatly obſtruct the Motion of *Sound?*

B. No, not ſo much as one would imagine; though there is ſome ſmall Difference in the *Velocity of Sound* with or againſt the Wind; but *Sound* is greatly augmented or diminiſhed by the Strength or Weakneſs of the Wind.

A. Is there any Difference in the Motion of great or ſmall *Sounds?*

B. Mr. *Derham* ſays, none at all; whether they be loud or languid, of Bells, Guns, *&c.* great or ſmall, or any other ſonorous Body.

A. How do you eſtimate the Greatneſs or Intenſity of *Sound?*

B. That, *Sir*, is always as the Space paſſed through by the Particles of undulating Air in their paſſive Motion backward and forward.

A. What further have you to obſerve to me concerning the Motion of *Sounds?*

B. They fly equal Spaces in equal Times, and nothing but the Wind can accelerate or retard them; not the Differences of *Day* or *Night*, *Summer* or *Winter*, *Heat* or *Cold*, *Weather* cloudy or clear, the *Air* heavy or light, *&c.*

A. Pray, *Sir*, tell me the Reaſon why after the *Stroke* the *Sound* of ſome Bodies, as Bells, the Strings of muſical Inſtruments, *&c.* continues ſo long, but weaker and weaker?

B. The *Sound* of Bodies endures in Proportion to the Number of Vibrations made therein by the *Stroke*, each Vibration producing a Wave in the Air, and each Wave repeating the *Sound*; but ſtill more fainter and more, as the Vibrations are leſs and leſs, till they entirely ceaſe: This is eaſy to be obſerved by the Ear in Bells, and by the Eye in a String under Tenſion.

A. There is one Thing more I had almoſt forgot to enquire the Reaſon of, tho' I gueſs how it muſt be; but I beg your Thoughts of it, *Sir*; it is an *Echo?*

B. This, *Sir*, is no more than the Repetition of *Sound*, made by a Reflexion or Repercuſſion of a Wave of *Sound*, from the Surface of impenetrable Obſtacles, as Walls, *&c.* whence flying back, it reſalutes our Ears with the ſame *Sound* again.

A. This is juſt as I apprehended it to be: But pray, *Sir*, whence ariſeth the great Variety in the Note or Tone of *Sounds?*

B. The Notes and Tones of *Sound* ariſe from the peculiar Nature of the ſonorous Body, the Manner and Degree of Percuſſion, and the different Make and Configuration of the Organ or Inſtrument of *Sound*; all theſe contribute to make that wonderful Variety and Difference in the Tunes, Notes, or Tones of *Sound*.

A. Why is it that ſome Notes, called Concords, are agreeable to the Ear, and others we call Diſcords diſagree therewith?

B. We may ſay, they are ſo from the Agreement or Diſagreement of the different Motions in the Air producing them; but a Perſon is little the wiſer for that: I therefore reſolve it into the Will, Power, and Goodneſs of the great Creator, who, doubtleſs, deſigned the pleaſing Harmony and Melody of *Sounds* to indulcorate and heighten the Pleaſures of humane Life, and to alleviate and diſpel its Cares.

CHAP. IX.

Of GRAVITY *and* LEVITY: *Of* ATTRACTION *and* ELECTRICITY.

A. PRAY, *Sir*, what is meant by the *Gravity* of Bodies?

B. That Property, Power, or Force, whereby all Bodies tend downwards, in right Lines, to the Center of the Earth.

A. Is not this what is called the *Weight* of Bodies?

B. No; for the *Weight* is properly the Effect of *Gravity*, or the Meaſure or Quantity of this Power acting on them.

A. How do you diſtinguiſh the Kinds of this Property?

B. Into abſolute and ſpecific *Gravity.*

A. What is abſolute *Gravity?*

B. All that Power whereby a Body tends towards the Center of the Earth.

A. And, how doth ſpecific *Gravity* differ therefrom?

B. The ſpecific or relative *Gravity*, is that which is peculiar and appropriate to any diſtinct Species of Bodies, and diſtinguiſheth them from others, when compared with them.

A. What is the Meaſure of the Property of *Gravity* in Bodies?

B. Their Quantity of Matter; for their *Weight* or *Gravity* is always proportional thereto.

A. Pray what do you call that Point towards which Bodies naturally tend?

B. The Center of *Gravity*, which is very near the Center of our Earth, for all Bodies within its Verge of Power: And thus the Center of *Gravity* of the Planets, is ſaid to be near to the Center of the Sun, about which therefore they all circulate.

A. In what Manner doth this Power of *Gravity* act on Bodies?

B. Equally and abſolutely on all alike, without Regard to their Figure, Size, or Quantity of Matter.

A. If ſo, one would think all Bodies would deſcend with equal Velocity or Swiftneſs.

B. So they would in Reality, were it not for the Reſiſtance of the Air.

A. This is a ſtrange Aſſertion! Pray how do you prove it?

B. By the *Air-Pump*; for put the lighteſt Feather and a Guinea together in the Receiver, holding them faſt at the Top till the Air be exhauſted, then letting them go, you will perceive them deſcend to the Bottom in the ſame Moment of Time, and with incredible Swiftneſs.

A. This is, indeed, very curious and wonderful, and almoſt paſt Belief, that the lighteſt Bodies ſhould deſcend as ſoon as the heavieſt!

B. Yes, they will in Vacuo, indeed: But in the reſiſting Medium of the Air, Bodies gravitate towards their common Center, and one another, according to their different Quantity of Matter contained in them, as I ſaid before.

A. What, *Sir*, do you ſay that Bodies gravitate towards one another?

B. Yes, they do: The *Moon* gravitates to the *Earth*, and ſo does the *Earth* to the *Moon*; the *Satellites* of *Jupiter* and *Saturn* to them; and *Jupiter* and *Saturn* gravitate to the *Satellites*; yea, the *Earth* gravitates or moves towards the *Stone* that falleth, as well as the *Stone* gravitates or moves towards the *Earth*.

A. Aye, indeed! why then, if the Earth moves towards all Bodies falling on it, how is it that we can never perceive it?

B. By reaſon of the vaſt Diſproportion of Matter in each; for ſuppoſe a Stone of 100 ſolid Feet in Magnitude, let fall from a Height equal to our *Chicheſter* Spire, *viz.* 300 Feet; then becauſe the Globe contains about 30000000000000000000000 ſolid Feet, and ſuppoſe the Earth every where to be of the ſame Denſity with common Stones, then the Quantity of Matter in the Earth will be to the Quantity of Matter in the aforeſaid Stone of 100 Feet, as 300000000000000000000 to 1; and therefore while the Stone falls 300 Feet, the Earth will move towards the Stone the

$$\frac{300}{300000000000000000000} \text{ or } \frac{1}{1000000000000000000}$$

Part of a Foot; which is ſo very ſmall a Matter as to be not only imperceptible to the Senſes, but inconceivable by the Imagination.

A. 'Tis in my Conſcience, indeed: But, *Sir*, now we are upon the Deſcent of heavy Bodies, pray at what Rate of Velocity doth a Body deſcend to any given Diſtance downright?

B. The perpendicular Deſcent of Bodies, is at the Rate of 15 Feet in one Second of a Minute; and for all the following Seconds, the Spaces are as the Square of the Seconds: Thus, ſuppoſe a Body keep falling 1, 2, 3, 4, *&c.* Seconds, the Squares of theſe Times will be 1, 4, 9, 16, *&c.* and the Spaces paſſed through at the End of each will be 15, 60, 144, 240, *&c.* and the exact Number of Feet paſſed through in each ſingle Second will be as the odd Numbers 1, 3, 5, 7, *&c.* that is, 15, 45, 75, 105, *&c.* Feet; all which is diſtinctly and naturally ſeen in the Line AB, *Fig.* XV.

A. I apprehend it very eaſily, *Sir*, and thank you for your Pains; and ſhould be yet further obliged, if you'll pleaſe to let me know in what Manner or Proportion the *Weight* of Bodies increaſes or decreaſes with Reſpect to their Diſtance from the Center of *Gravity*.

B. Sir, I ſhall have the utmoſt Delight to inform you; pleaſe to know therefore, that the *Weight* of Bodies is reciprocally as the Squares of the Diſtances from the Center of *Gravity*.

A. I ſhould be glad if you could exemplify it to my Apprehenſion.

B. That I can eaſily: Suppoſe ZPNS the Globe of our Earth, and its Center C, the Center of *Gravity*; let there be a Body placed on its Surface at Z, whoſe Weight let be 3600 Pounds; then if this Body be removed to the Diſtance CF, two Semi-diameters of the Earth, you have its Weight there by this Analogy 4 : 1 : : 3600 : 900. if the the ſaid Body were removed 3 Semi-diameters to E, the ſame Analogy finds its Weight there, *viz.* 9 : 1 : 3600 : 400. and at the Diſtance of 6 Semi-diameters, the Weight thereof will be but 100 Pounds for 36 : 1 : : 3600 : 100. Thus, at the Diſtance of 1, 2, 3, 4, 5, 6 Semi-diameters from the Center of the Earth, the Diminution of the Weight of ſuch a Body would be as theſe Numbers 3600, 900, 400, 225, 145, 100. Thus on the contrary; he who beareth 100 Pound Weight, on the Earth's Surface, would with equal Eaſe ſuſtain the Weight of 3600 Pounds at the Diſtances of 6 ½ Diameters at A. See *Fig.* XVI.

A. I thank you, *Sir*, for ſo clear an Illuſtration of this Affair: But after ſo much of the *Gravity* of Bodies, pray let me know what the Philoſophers ſay of the *Levity* of Bodies?

B. There is no ſuch Thing, philoſophically ſpeaking, as abſolute *Levity* or *Lightneſs*;

neſs; this is only a comparative Term, and implies no more than the Difference of the Weight of Bodies compared together, or their ſpecific *Gravity*.

A. Pray, what Diſtinction do you make between *Gravity* and *Attraction*?

B. In the Nature of the Thing there is no Difference, they are both one and the ſame Principle, only in the Manner of conſidering it this Diſtinction ariſeth; if we reſpect it in the Body, containing the Center of *Gravity*, we call this *Power*, in that Body, *Attraction*; but we call it *Gravity* in Bodies which are moved toward that Center, or Body, wherein it is: Thus the Earth is ſaid to attract Bodies on it, or falling on it; and thoſe Bodies are ſaid to gravitate towards the Earth; ſo the *Load-ſtone* attracts Steel, and the Steel gravitates to it.

A. Is this Power of *Attraction* the ſame in all Bodies, of the ſame Kind, of equal Denſity and Magnitude?

B. Yes; but in all ſuch Bodies, the leſs any one is than another, the greater is its attracting Force; ſo the *magnetic Attraction* is ſtronger in a ſmall *Load-ſtone*, in Proportion to its Weight, than in a larger one.

A. Pray, what is the Conſequence of this?

B. Sir *Iſaac Newton* has on this Score found, by Calculation, that, as the Particles of *Light* are the leaſt Bodies we know of, ſo their *Attraction* is 1000000000000000 Million of Millions of Times greater than that of the Earth, on the Earth's Surface; according to the Quantity of Matter in each, and the afore-mentioned Velocity of *Light*.

A. Pray, *Sir*, what do you underſtand by *Electricity?*

B. A certain Kind of attractive Faculty peculiar to ſome Bodies, as *Amber*, *Jet*, *Sealing-wax*, *Glaſs*, &c. whoſe Particles are ſuch, that being greatly rarified and agitated (by the Heat occaſioned by *Attrition* or rubbing of them) they fly off to a certain ſmall Diſtance,. but not beyond the Sphere of the Body's *Attraction*; and therefore by this *Attraction* they are obliged to return again to their old Quarters.

A. Why then, I ſuppoſe, it is by their flying off, that light Bodies, as *Feathers*, *Hairs*, &c. are repelled from the electrical Body, and by the Return of thoſe Particles, they are again inſtantly compelled back and attached to the ſaid Body.

B. Yes, that is the Caſe as underſtood at preſent; but for the real Cauſe of *Attraction* or *Gravity* in general, Sir *Iſaac Newton* profeſſeth himſelf entirely ignorant of it; even though he makes this Principle of

Attraction or *Gravity* the Baſis of all his Philoſophy: Wherefore let us now diſcourſe of ſome other Properties of natural Bodies.

CHAP. X.

Of Tranſparency and Opacity, Denſity, and Rarity, Hardneſs and Softneſs, Rigidity and Flexibility, in Bodies.

A. SIR, I thank you for thoſe Inſtructions concerning *Gravity* and *Attraction*, and ſhall be very glad to hear you farther on the other Qualities of Bodies; and firſt, what may we underſtand by the *Tranſparency* and *Opacity* of Bodies?

B. Tranſparency is that Quality of certain Bodies, whereby their Subſtance is enlightned, and Objects appear viſible through the ſame, as in *Glaſs*, *Chryſtal*, &c. and therefore thoſe Bodies are called *Tranſparent*, *Pellucid*, or *Diaphanous*, all which Terms imply the ſame Thing. *Opacity* is the Quality oppoſite hereto; and thoſe Bodies are ſaid to be *Opake*, whoſe Matter is not tranſparent, or through which Objects are not viſible.

A. Pray what is the Cauſe of theſe Qualities?

B. The Cauſe of *Tranſparency* is owing to that Conſtitution of Bodies which admits the *Rays of Light* to paſs through their Pores in right Lines, and in all Directions whatever; and on the contrary, *Opacity* is the Effect of *Light* obſtructed in its Paſſage through Bodies, or of that which is not tranſmitted in right Lines.

A. It ſeems to follow from hence, that the Matter of tranſparent Bodies muſt be very little in Proportion to their Pores.

B. Very little indeed; ſo little, that a celebrated Philoſopher queſtioned whether the Quantity of Matter in *Glaſs* were more in Proportion to its *Poroſity*, than one Grain of Sand to the Bulk of the whole Earth.

A. In what Proportion are Bodies *Tranſparent*?

B. In Proportion to the *Rarity* and *Denſity* of Matter.

A. What do you call the *Rarity* and *Denſity* of Matter?

B. By *Rarity* is underſtood the *Thinneſs* of the Particles of Matter; and by *Denſity*, the Thickneſs thereof; in Reſpect of the Bulk of Bodies.

A. Then the *Denſity* of Bodies hath Regard both to their Matter and Magnitude, I underſtand by this; but pray what Proportion?

B. The *Denſities* of two Bodies are in a Proportion compounded of the direct Proportion of their Quantities of Matter, and a reciprocal Proportion of their Magnitudes.

A. I believe I could better apprehend you, if you'd pleaſe, *Sir*, to exemplify this Matter.

B. I will: Thus ſuppoſe A be a Body which hath 8 Parts of Matter, and 5 Degrees of Magnitude; and B be a Body having 2 Parts of Matter, and 10 Degrees of Magnitude; then the *Denſity* of A will be to the *Denſity* of B, as $\frac{8}{2} \times \frac{10}{5} = \frac{80}{10} = \frac{8}{1}$, that is, $\frac{A}{B} = \frac{8}{1}$, or A : B :: 8 : 1; therefore the Body A's *Denſity* is 8 Times greater than the *Denſity* of the Body B.

A. Pray, *Sir*, what Means are thoſe Qualities moſt of all increaſed or diminiſhed by?

B. *Heat* and *Cold*; for *Heat* by dividing, extending, and expanding the Particles of Bodies, doth attenuate and rarify them, and this is called *Rarefaction*; on the contrary, *Cold* by uniting, and contracting the Particles of thin Bodies, doth thicken and condenſe them, and this is called *Condenſation*.

A. Pray do not the Hardneſs and Softneſs of Bodies ariſe from their *Denſity* and *Rarity*?

B. No, *Sir*, no: The Hardneſs of Bodies ariſeth from the mutual *Attraction* of the moſt minute primogenial Particles of Matter, whereby they firmly cohere, and are, as it were, conglutinated together: When this Firmity or Coheſion of Parts is ſo ſtrong, that the Preſſure of the Finger will not part or diſplace them, then we ſay ſuch Bodies are hard; but on the contrary, we call them ſoft Bodies, or ſuch as will yield to the Touch.

A. What Figure of thoſe primitive Particles of Matter is moſt requiſite to produce Hardneſs or Firmity of Bodies?

B. The nearer the Figures of thoſe Particles approach to the Figures of the 5 regular Bodies, or the greater their Superficies, by which they touch one another, the ſtronger will be their *Attraction*; and conſequently the greater their *Coheſion, Firmity*, or *Hardneſs*: But by how much leſs Superficies they touch, and the eaſier they ſlip and ſlide by and over each other, by ſo much the ſofter ſhall we find the Bodies; and this in various Degrees, even to *Liquidity*.

A. Is it not alſo to the Size, Shape, *&c.* of thoſe ſmall Particles of Matter, that the *Rigidity* and *Flexibility* of Bodies are owing?

B. No doubt of it, though it cannot be poſitively defined: But by the Analogy of

Reaſon, *Rigidity* or *Stiffneſs* of Bodies ſeems to depend on two Things: *Firſt*, an oblong Square-figured ſet of Particles, which are (*ſecondly*) unequally placed or jointed together, as thus ( ) for the Want of *Poroſity*, and the mutual *Attraction*, with the Reſiſtance ariſing from the Poſition of Particles, will cauſe *Rigidity*; and by how much leſs Particles are endued with ſuch Modifications, by ſo much the more Bodies are flexible or liable to bend; whence their *Flexibility*.

CHAP. XI.

Of Conſiſtence and Fluidity, Heat and Cold, Humidity and Siccity, Elaſticity, Odours, and Sapours of Bodies.

A. PRAY what do you mean by the *Conſiſtence* of Bodies?

B. That State of Bodies whereby the conſtituent Particles do naturally keep the ſame Poſition to each other, and are not to be moved or ſeparated but by ſome coercive, external Force; whence this Quality is alſo called the *Fixity* of Bodies.

A. Whence doth this *Fixity* or *Conſiſtence* of Bodies ariſe?

B. Un-

B. Undoubtedly from the Figure, Size, and Attraction of the conſtituent Particles, of the ſame Sort with thoſe which produce *Hardneſs* and *Rigidity* of Bodies.

A. Pray is not *Fluidity* oppoſite to *Conſiſtence*? And doth it not ariſe from contrary Cauſes?

B. Yes: *Fluidity* is that State of natural Bodies, whereby their Particles are always in a Flow; and are equally diſpoſed to move in any Direction by the leaſt Impreſſion.

A. What may be the Cauſe of *Fluidity*?

B. The exceeding Tenuity or Smallneſs, Sphericity or Roundneſs, Lubricity or ſmooth Slipperineſs, and Similarity, or Likeneſs of the primogenial, conſtituent Particles of Matter: For Particles thus modified muſt always produce a fluid Body, or Subſtance, as *Water*, *Fire*, &c.

A. Is there any Difference between *Fluidity* and *Liquidity*?

B. Yes, yes, a great Deal: For *Fluidity* is a general Name for all Bodies whoſe Parts yeild to any Impreſſion; and thus a Quantity of Sand as well as Water is called a Fluid; but what we properly call a Liquid, or Liquor, is only that Kind or Species of Fluids which cleaveth to the Touch, or ſticketh to the Finger, *&c.* which toucheth it; and, as we may ſay, wetteth it, as doth Water, or any Kind of Juices.

A. What, *Sir*, may be the Reaſon or Cauſe of this Difference?

B. It is owing to the exceeding Smallneſs of the Particles of Liquids above thoſe of fluid Bodies; and alſo to their Weight, or Ponderoſity: For, by theſe Means, the Particles of Liquids enter the Pores of the Body which toucheth it; and by their Weight and Gravity, cohere to, and abide therein; and ſo cauſeth Wetneſs.

A. Pleaſe now to let me know, *Sir*, what your Sentiments are of *Heat* and *Cold* in Bodies, and wherein thoſe Qualities do conſiſt?

B. Heat is a Senſation excited in the Mind by a great Agitation of the Particles of the hot Body, which exerteth its Action or Influence on us; ſo that *Heat* in us is only the Idea thereof; and in the hot Body, Activity or Motion, and Nothing elſe: No *Heat* is ſenſible to us, unleſs the Motion of the Parts of a Body, which acts on us, be greater than the Motion of the Organ or Part of the Body acted upon. When the Motion of the Parts of the Body are leſs than that of our Organs of Feeling, then it occaſions in us the Senſation or Idea of *Cold* or *Coldneſs.*

A. Then, if I take you right, *Sir*, the Reaſon or Difference of *Heat* and *Cold*, for Inſtance, in Water, lieth in this: That in the firſt Caſe, the Particles are by the Fire put into a greater Motion and Agitation than is in the Hand that feeleth it; and, in the latter Caſe, the Motion of the aqueous Particles is in a leſs Degree than of thoſe in the Hand; and thus we find it to be either *Hot* or *Cold*.

B. Yes, that is the true Nature of the Caſe, according to modern Philoſophy and manifold Experiments.

A. Pray how do you conceive of *Flame*?

B. As a *Fluid*, whoſe Parts are ever in Motion, inſenſible, and inconceivably great; and which ſeems to depend on the Air, in its natural State; becauſe a Candle will not burn in aduſt, or burnt Air, as is found by Experiment.

A. Is not *Light* and *Fire* pretty much the ſame Thing, or of the ſame Nature?

B. The Particles of *Light* and *Fire* agree in ſeveral Things, *viz.* 1. In their Smallneſs: 2. Their Luminoſity: 3. Their exceeding Activity: 4. Their Heat, or burning Quality: For the Rays of the Sun, collected together by a burning Glaſs, burn more violently than any common Fire; it kindleth *Wood* in a Moment; immediately makes *Iron* or *Steel* red hot; melts *Silver*, *Gold*, &c. in ½ a Minute; turns *Bones* into a *black Glaſs*; and *Brick*, *Tiles*, and *Earth* it ſelf, to *green Glaſs*, in an Inſtant; from whence we muſt infer the Particles of *Light* and *Fire* are the ſame.

A. This ſeems a juſt Inference indeed: But, becauſe we cannot be large on every Head, pray give me a ſmall Account of the Qualities called the *Humidity* and *Siccity* of Bodies.

B. Humidity, or *Moiſture* of Bodies, is only a Mixture of the Particles of Liquor with thoſe of the ſolid Matter of Bodies; thus Particles of Water, mixed with Earth, make it humid and moiſt; thus the Juices of Vegetables make their Subſtance moiſt; and the Want or Defect of this Moiſture, or liquid Subſtance in Bodies, is what we call *Siccity* or *Dryneſs*; and which, in moiſt Bodies, is occaſioned by the Sun, Fire, Wind, *&c.* by attenuating and rarifying the liquid Particles, and thereby cauſing them to fly off in *Steam*, or inſenſible *Vapour.*

A. In the next Place, pray, *Sir*, tell me what that Property is in Body which you call *Elaſticity?*

B. It is that Diſpoſition of ſome Bodies, whereby when the Parts of the Body by Preſſure are put out of their Place and Form, they immediately again return to, or recover their firſt Poſition and Figure.

A. Pray whence doth this Property proceed?

B. 'Tis hard to ſay what are the particular Circumſtances of the Cauſe of *Elaſticity*; however 'tis certainly owing to the ſpecial Figure, Surfaces, and Attraction of the Parts of elaſtick Bodies.

A. Are all Bodies elaſtick?

B. Yes, in a greater or leſſer Degree; but none are perfectly elaſtick.

A. Pray what do you call perfect *Elaſticity*?

B. That, whereby a Body recovers its Figure by the ſame Force it loſt it.

A. Is there any Thing remarkable in the Motion of Bodies derived from their *Elaſticity*?

B. Yes: If an elaſtick Body A, ſtrikes againſt the firm Bottom CD, obliquely in the Direction AF, it will always rebound again in the ſame Obliquity FE, or ſo that the Angle EFD, ſhall always be equal to the Angle AFC. See *Fig.* XVII. Beſides this, there are many other Properties of the Motion of ſpringy or elaſtic Bodies, ariſing from their *Spring* or *Elaſticity*; for which larger Volumes muſt be conſulted.

A. Well then, leaving that, let us proceed to what you call the *Odours* of Bodies; pray what are they, or wherein do they conſiſt?

B. The *Odours* of Bodies, by affecting the Organ of Smelling, *viz.* the Noſe, do raiſe and excite in us the Senſation we call Smell, or Scent: Theſe *Odours* of Bodies are nothing but *Effluvia*, or exceeding fine and inſenſible Particles, flying off the *odoriferous* Bodies in all Directions; and as they float in the Air, ſtrike againſt, and cauſe in our Noſtrils the aforeſaid Senſation of Smell.

A. In what Degree or Proportion are thoſe *Effluvia*, or *Odours*, ſenſible to us?

B. The Senſation which they excite in us, or the Degree or Intenſity of Smell, is always in Proportion to their *Denſity* or *Thickneſs* where we are; and this *Denſity* is always diminiſhed in Proportion to the Squares of the Diſtances from the *odorous* Bodies.

A. Pray, *Sir*, can you not make this ſomewhat more evident and plain by Example?

B. Yes, ſurely; for to that End doth Example ſerve: Let therefore R repreſent a Roſe, and the Dots about it, the Emanations of numberleſs *Effluvia* of *Odours*; now ſuppoſe your Noſe in three ſeveral Diſtances at A, B, and C, which let be 1, 2, and 3 Feet from the Center of the Roſe: Now, I ſay, the Degree, or Intenſity of the Smell, at thoſe Diſtances, will diminiſh in Proportion to the Squares thereof 1, 4, 9. *i. e.* it will be 4 Times leſs at B than at A; and 9 Times leſs at C than at A: Do you apprehend it now? See *Fig.* XVIII.

A. Very well, *Sir*, and am obliged to you: But, pray, *Sir*, how comes it about that ſome irrational Animals, eſpecially ſome Dogs, can ſmell any Thing at ſo much greater Diſtance than we can?

B. This is entirely owing to the greater Perfection of that Organ in thoſe Creatures than in Man, as being on many Accounts more neceſſary in them than in us; for in them, God has made it one Means to preſerve Life; in us he ſeems to have deſigned little more than Gratification and Pleaſure thereby.

A. Pray whence do *Sapours* or *Taſtes* of Bodies ariſe?

B. From a certain, determinate Magnitude and Figure of the Particles of the *ſaporific* Body; which in the Make of the Tongue, do thereby occaſion the Senſe of *Taſte* in all Varieties, according to the different Modification and Configuration of thoſe *ſaporiferous* Particles.

A. But, what are thoſe Sizes and Figures of Particles neceſſary to qualify them to exert this *ſaporific* Virtue, which you ſpeak of?

B. No Man knows that; we ſhould be contented to have a general Knowledge, when Particulars are denied us; we had better confeſs our Ignorance in Naturals, and adore the ſuperlative Wiſdom of God, who hath made it his own Prerogative to know all Things; than feign vain or abſurd Hypotheſes, with an ambitious and im-

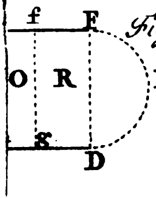


Fig XIII.

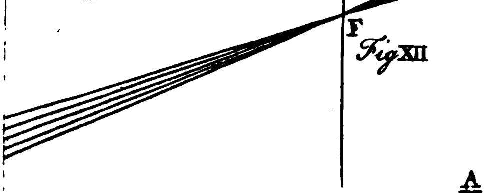


Fig XII

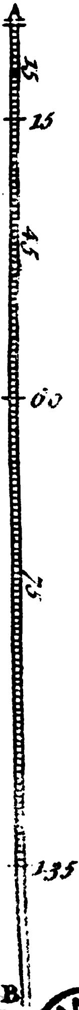
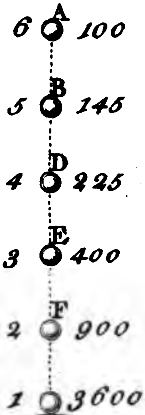


Fig XV.



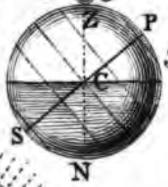


Fig XVI.

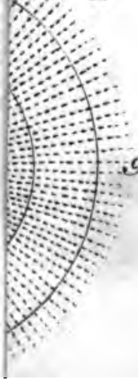


Fig XVIII.

UNIV.

Impious View of being thought Omniſcient, or able to account for all Things.

A. I think ſo too indeed, good *Sir*, and ask Pardon for being ſometimes too curiouſly inquiſitive about the *Arcana* of Nature.

B. Sir, we are allowed, yea, 'tis our Duty, to improve our Knowledge, and communicate the ſame to each other ſo far as we are capable: And having taken this particular Survey of the Properties and Qualities of Bodies; let us proceed to a general View of the Univerſe compoſed thereof.

CHAP. XII.

Of Sir ISAAC NEWTON'S *Laws of Nature.*

B. BUT, before we launch out into the boundleſs Extenſion of the Univerſe, where we ſhall ſee every Thing in Motion all about us; it will be proper previouſly to conſider that (though we have already ſeen the general Properties and Phænomena of Motion, yet) there are ſome ſtated certain *Rules*, or *Laws*, by which all the Motions of all natural Bodies are conſtantly governed and determined; and by which every Thing relating to Motion may be explained.

A. Pray how many are thoſe *Laws?*

B. Sir *Iſaac Newton* has laid down three ——.

A. But, pray, if you pleaſe, tell me why they are called Sir *Iſaac Newton*'s *Laws* of *Nature?*

B. That is more than I can do: Sir *Iſaac* was not the firſt Inventor of them, ſince if you pleaſe, you may ſee them in Monſieur *Deſcarte*'s Philoſophy, which was before Sir *Iſaac*'s appeared.

A. Well, we will ſuppoſe it then the Effect of a fond Indulgence to a great Man of our own Country; but, pray, what are thoſe *Laws.*

B. The *firſt* is this:

LAW I.

All Bodies continue in their State of Reſt, or Motion, uniformly in a right Line, excepting they are obliged to change that State by Forces impreſſed.

A. What is the Foundation of this *Law?*

B. We ſee all Bodies, by their Nature, are inactive and incapable of moving themſelves; wherefore, unleſs they be moved by ſome external Agent, they muſt neceſſarily remain for ever at Reſt.

A. But why muſt a Body in Motion, if left to it ſelf, for ever ſo continue in a right lined Courſe?

B. We know this by daily Experience; for when any Body is put into Motion, it continues to move in the ſame rectilineal Direction, and with the ſame Velocity; until the Reſiſtance of the Air, the Power of its own Gravity, the Make of the Body, or ſome other external Cauſe, determines it from a right-lined Direction, diminiſhes its Velocity, and brings it at laſt to a State of Reſt.

A. If this be the Caſe, pray how comes it to paſs that the *Sun*, *Moon*, *Comets*, &c. continue their Motion ſo long; have the Regions, through which they move, no Reſiſtance?

B. The Bodies of the *Planets* and *Comets* are vaſtly great; and the Spaces, through which they move, have ſmall Reſiſtance, by which Means they conſerve their Motions the longer.

A. Pray what is the next *Law* of *Nature*?

B. The *ſecond Law* is this:

LAW II.

All Change of Motion is proportional to the Power of the moving Force impreſſed; and is always made according to the right Line in which that Force is impreſſed.

A. What do you obſerve from thence?

B. That if any Power produceth any Motion; another Power which is double, triple, *&c.* will produce a double, triple, *&c.* Quantity of Motion; whether it be impreſſed together, and at once, or ſucceſſively by Degrees: And this Motion (becauſe it is ever determined towards the ſame Part with the generating Force) is added to the Motion of a Body in the ſame Direction by Impact, and it will move ſo much the quicker; but it is ſubtracted from the Motion of a Body in contrary Direction, and therefore that Body will move ſo much the ſlower. It is alſo obliquely joined to the Motion of a Body obliquely moving; and will be compounded with it according to the Determination of both. Hence a very conſiderable Conſequence will follow.

A. Pray what is that?

B. Why, according to the preſent Conſtitution of Things, it follows from this *Law*, there can be no perpetual Motion; for by this *Law*, the Motion produced is but proportional to the generating Force; and all Motions on this Globe being performed in a reſiſting Medium, *viz.* the Air, a conſiderable Quantity of the Motion muſt, in the Communication, be ſpent on this Medium; and conſequently 'tis impoſſible the ſame Quantity ſhould return undiminiſhed upon the firſt Mover, which yet, is neceſſary towards a perpetual Motion: Beſides that ſuch a Diminution of Motion will be greatly increaſed by the conſtant Friction of the Parts of the Machine; for there will be more or leſs of that, be the Inſtrument ever ſo well contrived, there being no ſuch Thing as abſolute Smoothneſs, or perfect Congruity, in Nature; at leaſt, not in any of the Works of Man.

A. Pray what is the *third Law*?

B. This:

L A W III.

Repulſe, or Re-action, is always equal, and in contrary Direction, to Impulſe, or Action, *i. e.* the Actions of two Bodies upon each other is always equal, and in contrary Directions.

A. Pray can you not illuſtrate this Matter a little by a familiar Inſtance or two?

B. Yes: Thus, if you preſs a Stone with your Finger downward, the Stone equally preſſes your Finger again upward: If a Horſe draw forward a Stone tied to a Rope, the Stone equally draws back the Horſe; for the Rope being equally diſtended both Ways, acts on both Horſe and Stone equally: The Anvil ſtrikes the Sledge with the ſame Force the Sledge ſtrikes it, which therefore rebounds or flies back: The Steel draws the Magnet, as much as it doth the Steel; as is evident by making both ſwim in Water. When a Barge is pulled to the Bank by a Rope, the Bank pulls the Barge as much as the Barge-Man pulls the Bank: And in the Deſcent of heavy Bodies, the Stone that falls attracts the Earth as much as the Earth does it; that is, the Motion of the Earth is equal and contrary to that of the Stone.

A. Why theſe are all *Paradoxes* ſurely; I cannot conceive how it can be, nor believe that the Earth moves as much towards the Stone as the Stone does towards it, in falling.

B. But it is true, and is what I proved to you, if you remember, when we diſcourſed of the Gravitation of Bodies towards each other. I there ſhewed the Reaſon we cannot ſee ſuch a Motion of the Earth, is becauſe of the incomprehenſible Diſparity of the Velocities of the Stone and the Earth: For, as I ſhewed you on the Subject of the Motion of Bodies, the Motions of any two Bodies may be equal to each other, when the Velocities of their Motions are infinitely different.

A. 'Tis true, I remember you did ſo; and I find what creates the Wonder, is only a miſtaking of Velocity for Motion, which is an entire different Thing.

B. Yes, it is ſo; and in moſt Caſes, were the true Nature and Differences of Things well attended to, we ſhould not be ſo liable to inglorious Wonder and Aſtoniſhment (the conſtant Effect of Ignorance) as we too commonly are. On this third *Law* depends all the Reaſon of the Compoſition and Reſolution of *Motion* and *Forces*; which I explained to you, when we talked of *Motion*, by *Fig*. X. But, now, let us extend our View over the *univerſal Space*.

THE

Philoſophical Grammar:

Or, VIEW of

Modern Philoſophy.

PART II.

COSMOLOGY:

CONTAINING,

I. A general View of the *Univerſe.*
II. The Philoſophy of the *Sun.*
III. The Philoſophy of the *Moon.*
IV. The Philoſophy of the *Planets.*
V. The Philoſophy of the *Comets.*
VI. The Philoſophy of the *fixed Stars.*

Explaining their *Nature*, *Properties*, and *Affections*, in ſo far as they are at preſent known and underſtood.

CHAP. I.

Of Coſmology in general, of the mundane Space, of a Vacuum, of Duration or Time.

A. WHY do you call the ſecond grand Diviſion of the Science of Nature *Coſmology?*

B. On account of the Congruity and Propriety of the original Senſe of the Word, with the Things which are the Subjects of the Science intended thereby.

A. What is originally imported by the Word *Coſmology?*

B. It is compoſed of the two Greek Words, Κοσμος, the *World*, and Λογος, a *Diſcourſe*; and therefore by *Coſmology*, is implied a philoſophical or phyſiological *Diſcourſe* of the *World*, or *Univerſe* in general.

A. In what Manner, or Order, then, I pray, do you deſign to proceed in taking this general View, or Survey of the *Univerſe?*

B. In the *firſt* Place, to obſerve the Order and Conſtitution of it, ſo far as it is known, with the ſeveral Parts thereof great and ſmall. *Secondly*, we will take ſome Notice of the mundane *Space*; in which, the various Parts or Bodies of the *Univerſe* do conſiſt, and are poſited here and there. *Thirdly*, we ſhall diſcourſe a little of the Nature of *Duration* or *Time*, whereby the Motions of all the Bodies in the *Univerſe* are meaſured.

A. This will be very delightful indeed, pray make a Beginning; what do you firſt obſerve in the general Conſtitution or Frame.

B. The firſt great *Phænomenon* of the *Univerſe*, which more eminently ſtrikes our Senſes, is that glorious Luminary we call the *Sun*, the Source of *Light*, and Center of our *planetary Syſtem*, or about which the *Chorus* of all the *Planets* move.

A. What, do you ſuppoſe the *Sun* to be the Center of the *Planets* Motions, and not a moving *Planet* it ſelf?

B. Yes; the *Sun* is in the Center of our Syſtem, around which the primary *Planets* move. See *Fig.* XIX.

A. Pray which, and how many are thoſe you call primary *Planets?*

B. They are in Number ſix; and their Names are *Mercury*, *Venus*, the *Earth*, *Mars*, *Jupiter*, and *Saturn*; theſe, in different ſtated Periods of Time, all revolve about the *Sun*, in the Order I have rehearſed their Names.

A. But, pray, what becomes of the *Moon*, that you mention her not amongſt the *Planets?* And, how came you to make a *Planet* of this *Earth* in her ſtead?

B. I am taught by the modern *Phyſiology* ſo to do; 'tis very certain the *Earth* is a *Planet*, and moves about the *Sun* with the reſt: And, as to the *Moon*, I do not ſay ſhe is not a *Planet*, but not a primary or principal one.

A. Why, *Sir*, what Difference do you make in the Kind of *Planets?*

B. There is diſcovered a two-fold Kind of *Planets*, viz. There are ſome very great and large ones, which regard the *Sun* as the Center of their Motions; theſe are called primary *Planets*, and are thoſe before named: Again, there are other leſſer ones, called *Satellites*, or *Attendants*, which circulate round ſome primary *Planet*, as their Center; and theſe are termed ſecundary *Planets*, and ſuch an one is the *Moon*.

A. Sure 'twill be thought very ſtrange, that the *Moon* (which next to the *Sun*, is the greateſt Luminary in the Heavens) ſhould be eſteemed only as a ſmall ſecondary *Planet*; the *Moon* is little obliged to your new Philoſophy, being thus degraded from her antient ſhining Poſt amongſt the primary ones!

B. What I ſay on this Head is founded on Reaſon, Obſervations, and Experiments; and therefore claims Belief before thoſe Notions which depend only on vulgar Senſe, and were the Products of a moſt rude and barbarous Age, though ever ſo glaring: Remember, *all is not Gold that gliſters.*

A. Well, I am glad to meet with Truth, whatever I exchange for it: But what do you next obſerve in this wondrous *Frame?*

B. The amazing Bodies we call *Comets*; which make ſuch prodigious Excurſions into the unknown diſtant Regions of the *Univerſe*, as to take up (ſome of them) ſeveral hundred Years in making one Revolution about the *Sun.*

A. I ſuppoſe by *Comets*, you mean blazing *Stars*; and do they likewiſe move about the *Sun?*

B. Yes; but in Orbits vaſtly eccentric, and approaching nearer to the Form of a *Parabola*, than an *Ellipſis* or *Circle.*

A. Well, what next to theſe offer for the Subject of our Contemplation, in this univerſal Scene?

B. The fixed Stars, which enamel and beſpangle the concave Expanſe, or Canopy of Heaven; which by their Numbers and Luſtre, make the Night beauteous and delightful, which would be otherwiſe dark and horrible: And thus I have rehearſed to you all the great Parts of which the World doth conſiſt, ſo far as we know any Thing of it.

A. Pray what is the Form or Figure of the *Univerſe*?

B. It hath no determinate Form or Figure at all; foraſmuch as it is every way infinite and unlimited.

A. Pray what do you call the mundane *Space*?

B. The infinite *Space*, in which all Bodies of the *Univerſe* have their Place and Being.

A. Pray what do you properly call *Space*?

B. Extenſion without Matter; or, in plain Engliſh, a perfect Void, or Vacuity; which is better conceived than defined.

A. What is that the Philoſophers call a *Vacuum*?

B. A *Vacuum* is a perfect Void, or Space abſolutely devoid of all Body or Matter; as on the contrary, they call that a *Plenum*, when any Part of *Space* is ſo abſolutely filled with Matter, as to have no Vacuities therein.

A. Is there any ſuch Thing as a *Vacuum* in Nature, I pray?

B. Yes; only thoſe who have denied their Reaſon, have denied this; or elſe have been ſuch miſerable poor Philoſophers as not to know what *Vacuum*, or *Nature* meant.

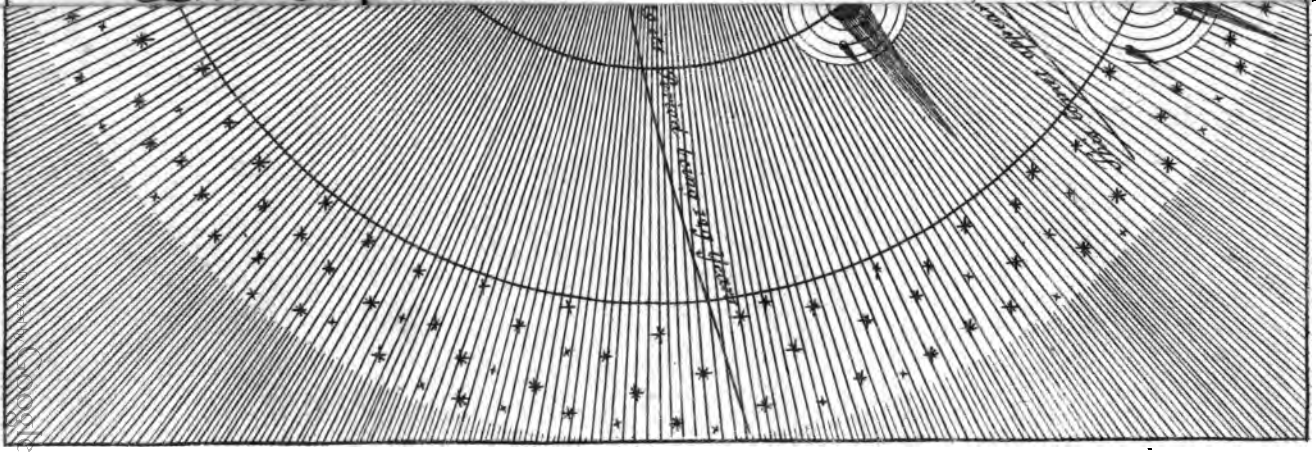
A. How do you prove a *Vacuum?*

B. A thouſand Ways almoſt; but Motion evinceth it moſt plainly, for can any one ſuppoſe a Body to move in the midſt of *Solidity?* They who affirm this, may as rationally affirm that a Bird may fly through a Mountain of *Adamant*, as eaſily as through the open *Air:* And who ſo blind as not to ſee the moſt monſtrous Abſurdity thereof by this one Argument?

A. I think none can deny it indeed, who would be thought rational: But, pray, what have you to ſay of *Duration* or *Time?*

B. Duration is the Idea we have of the Continuance of the Exiſtence, or Being of Things; and in order to eſtimate or meaſure the Parts thereof, we uſe the Motions of moving Bodies, as the Sun, Stars, a Clock, *&c.* and the Parts of *Duration* thus compared and meaſured, we call Time, Times, Seaſons, Ages, *&c.*

The Copernican *or* Solar Syſtem .



Bowen Sculp.t

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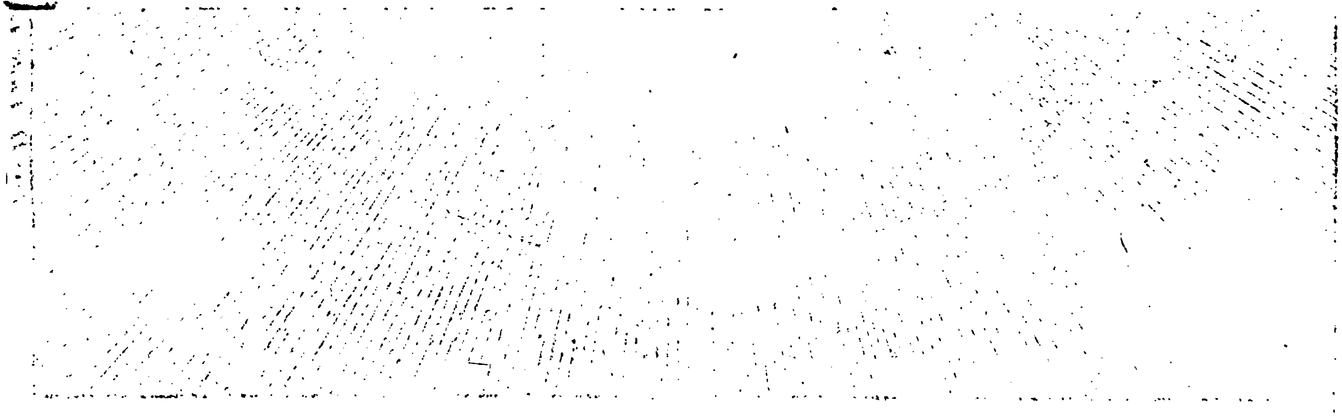


CHAP. II.

Of Uranology, or the Doctrine of the heavenly Bodies; and firſt of Heliography, or the Philoſophy of the Sun.

A. WHAT is the meaning of the Word *Uranology?*

B. It is of *Greek* original, and is compoſed of Ουρανος, *Heaven*, and Λογος, a *Diſcourſe*; therefore it ſignifies a *Diſcourſe* or *Treatiſe* of the *Heavens*, or *heavenly Regions*, and Bodies therein.

A. Pray what do you call the *Heavens*, or *heavenly Regions?*

B. Thoſe Regions, or Fields of Æther, which lie all around us above the *Atmoſphere*; in which are ſituated all the ſhining Bodies, the *Sun*, *Planets*, *Comets*, and *Stars*, and wherein they perform all their Motions.

A. Where will it be proper for us to commence our Converſations on theſe celeſtial Subjects?

B. We will firſt begin with *Helicgraphy*, if you pleaſe.

A. I do not underſtand the proper Meaning of that Word, pleaſe therefore to unfold it.

B. By *Heliography* (as being compoſed of ῾Ηλιος, the *Sun*, and Γραφὴ, a *Deſcription*) is to be underſtood, a philoſophical Deſcription of the *Sun.*

A. Well, it ſeems very congruous to begin with what you make the Center of our Syſtem, as you call it; and pray what do you firſt obſerve of the *Sun?*

B. The *Sun* is a huge Body of Light, or Fire, whence all the other *Planets* receive their Light; and by whoſe Emanations of Rays and Beams of Light, the whole Syſtem of Beings about us is illuminated and made viſible.

A. Pray can you tell any Thing of the *Sun's* Bulk?

B. Yes: The Diameter of the *Sun* is computed 822148 *Engliſh* Miles; and its Bulk, or ſolid Content, at 290971000000000000 Miles; which is about 1000000, or a Million of Times greater than the Globe of our Earth.

A. Stupendous Magnitude! And what, do you ſuppoſe it to be all Fire?

B. Yes; and therefore ſome have thought it to be the Place of Hell: However, its Quantity of Matter is well known; and the Denſity thereof is very conſiderable.

A. The Quantity of Matter, pray in what Proportion is that to the ſame in other *Planets?*

B, The Quantity of Matter in the *Sun* is to that in *Saturn*, as 100000 to 92; to that in *Jupiter*, as 100000 to 33; to that in our *Earth*, as 10000000 to 59.

A. In what Proportion is the Weight of Bodies on the *Sun's* Surface?

B. The Weight of equal Bodies on the Surface of the *Sun* is to their Weight on the Surface of *Saturn*, as 10000 to 943; to their Weight on *Jupiter*, as 10000 to 529; and to their Weight on the Surface of our *Earth*, as 10000 to 435.

A. What is the comparative Denſity of the *Sun?*

B. The Denſity of the *Sun* is to the Denſity of *Saturn*, as 100 to 94½; to the Denſity of *Jupiter*, as 100 to 67; and to the Denſity of our *Earth*, as 100 to 400, or as 1 to 4; and therefore the Fire of the *Sun* muſt be prodigious intenſe, yea, almoſt ſolid, as being one Quarter of the Denſity of our *Earth.*

A. Why, then the Light and Heat muſt be inconceivably great near the *Sun's* Surface!

B. Yes, great indeed: Sir *Iſaac Newton* ſaith the *Sun's* Light and Heat, at the Diſtance of *Mercury*, is 7 Times as great as the greateſt with us; and therefore our Water there would be for ever Boiling-hot, 'till it was all evaporated, and boiled away.

A. Is the *Sun's* Body one pure unmixed Subſtance of Fire?

B. That none can certainly tell; there hath ſeemed Reaſon to doubt it, ſince the Diſcovery of the *Maculæ Solares*, or *Solar Spots*.

A. Pray, *Sir*, what are they?

B. The Aſtronomers of late, by proper Glaſſes, have diſcovered many black Spots in the apparent Face of the *Sun*; ſome ſuppoſe they are a heterogeneous Mixture of opake Matter in the Body of the *Sun*, which therefore in thoſe Parts will always appear dark or black. Some of thoſe Spots ſeem to be generated in the very Middle of the *Sun*'s Disk; and others ſeem to be diſſolved and vaniſh there; ſometimes ſeveral ſmall ones gather together, and make a large Spot; and ſometimes a large Spot is obſerved to be divided and cut into many leſſer ones. Some Philoſophers have thought they were ſmall *Planets* circulating round the *Sun's* Body very near it; and others have other Conjectures about them. They were firſt diſcovered by *Galileus*, the *Italian* Philoſopher, in the Year 1610.

A. Do theſe Spots appear fixed, or in Motion, on the *Sun's* Body?

B. They all appear to move from the *Eaſtern* to the *Weſtern* Limb of the *Sun*, in about 12 or 13 Days.

A. Pray what do you infer from thence?

B. Why, was it certainly known (as it is the general Opinion) that thoſe Spots were really in the *Sun's* Body; then from their apparent Motion, we could be aſſured of the *Sun's* real Motion about its own Axis, in ſomewhat above 25 Days and 6 Hours: But if theſe Spots are only ſome diſtinct Bodies actually moving round the *Sun*, then we have no certain Knowledge that the *Sun* hath any real and proper Motion at all.

A. How, *Sir*, do you ſay no Motion at all; pray do we not ſee him move every Day from *Eaſt* to *Weſt*?

B. He ſeemeth, indeed, to us ſo to move; but that is one of the Fallacies of Sight, and indeed the greateſt.

A. What! *Sir*, can you pretend to ſay he doth not move?

B. Yes, *Sir*, there is no Reaſon to think he doth move; and there is little leſs than a phyſical Demonſtration that he doth not move.

A. Pray what is that?

B. It is in ſhort this: That ſince the *Sun*, the *Earth*, and all the *Planets*, gravitate mutually towards each other, they muſt all have one common Center of Gravity,

vity, about which they muſt all move; but Sir *Iſaac* hath ſhewn and demonſtrated, that this Point, or Center of Gravity, is not quite a Diameter of the *Sun*, diſtant from the *Sun's* Center; therefore the *Earth*, and all the *Planets*, move round a Point not half a Diameter of the *Sun*, diſtant from the *Sun's* Surface; and this is the ſame Thing to us, as if the *Earth*, &c. moved about the *Sun* it ſelf.

A. Well, I cannot confute Sir *Iſaac*, 'tis true; but I can chooſe whether I will believe him: Should not I ſooner believe the Word of God, and my own Senſes?

B. No: A Demonſtration at once commands Aſſent, maugre the literal Meaning of Scripture, and the Evidence of all our Senſes to the contrary. No one needs be convinced of the Fallacy of Sight, who hath ever been in a Ship under Sail; and the Scripture was not intended for a Syſtem of *Phyſiology*.

CHAP. III.

Selenography, or the Philoſophy of the Moon.

A. PRAY what is the Etymology of the Word *Selenography*?

B. It is compounded of Σελήνη, the *Moon*, and Γραφὴ, a *Deſcription*; wherefore it means a phyſiological Deſcription of the *Moon.*

A. You ſpeak of the *Moon* in the ſingular, as if there was but one; whereas juſt now you numbered our *Moon* with ſeveral others.

B. Yes, there are ſeveral other *Moons*, as *Jupiter* hath 4 *Moons*, and *Saturn* hath 5 *Moons*; but becauſe we know little more of them than their Number, Motions, and Diſtances from their *primary Planets*, we ſhall omit them here, and ſpeak of them together with their Primaries, by and by.

A. Well, ſince the *Moon* is favoured with the Preheminence to be conſidered alone; pray what do you firſt obſerve in her?

B. 'Tis found that the Body of the *Moon* is a large dark, opake, ſpherical Body, analogous to our Earth in Matter and Form.

A. What Proportion doth the *Moon* bear to the Earth in its Magnitude and Denſity of Matter?

B. The Bulk of the *Moon* is to that of the *Earth*, as 5386333000 to 258445900000, or as 5 to 258; that is, the *Earth* is about 50 Times (at leaſt) bigger than the *Moon*; the Denſity of the *Moon* is to the Denſity of the *Earth*, as 4891 to 4000, or as 11 to 9; the Quantity of Matter in the *Moon* is to that of the *Earth*, as 1 to 40, or as 1000 to 39788, more nearly; and the Weight of Bodies on the *Moon's* Surface, is to their Weight on the *Earth's* Surface, as 34 to 100.

A. Pray, *Sir*, can you tell the particular Dimenſions of the *Moon*'s Body in *Engliſh* Meaſure?

B. Yes: The Diameter of the *Moon* is 2175 *Engliſh* Miles, her Circumference therefore muſt be 6829 Miles; whence the Superficies of the *Moon* will contain 14855440 ſquare Miles, and her ſolid Content will be 5386333000 cubick Miles, as before.

A. On what do theſe Meaſures depend?

B. On the Diſtance of the *Moon* from the *Earth*; which ſome Aſtronomers make 59, ſome 60, ſome 61, Semi-diameters of the *Earth*, that is, about 238920 *Engliſh* Miles; whence the Diameter of the *Moon's* Orb will be 477840 Miles, and Circumference thereof 1500418 Miles; which therefore is the Journey the *Moon* performs every Revolution.

A. Then you do allow the *Moon* to move about the *Earth* every Day from *Eaſt* to *Weſt*, though you deny this to the *Sun.*

B. The *Moon* doth, indeed, move about the *Earth*, and that in about 27 Days, 7 Hours, and 43 Minutes, at a mean Rate: But this Motion is not from *Eaſt* to *Weſt*, but on the contrary, from *Weſt* to *Eaſt*, every Day about 13 Degrees and 10 Minutes.

A. How comes it then to appear to do thus?

B. By reaſon of the daily Motion of the *Earth* about its own Axis from *Weſt* to *Eaſt* once in 24 Hours; which maketh the *Sun*, *Moon*, and all the *heavenly Bodies*, appear to move the contrary Way from *Eaſt* to *Weſt* in the ſame Time.

A. Pray why do we ſee the *Moon* riſe and ſet above an Hour later every Day than another?

B. I ſhall make this eaſy to conceive: Thus, ſuppoſe T be the Globe of the *Earth*, WSEN the Orb of the *Moon*; let AD repreſent the *Horizon*, in which let the *Moon* ☽ be on any Day, at her riſing and ſetting, in E and W: Now, becauſe the *Moon* moves every Day about 13° 10′ from *Weſt* to *Eaſt*, let that Diſtance be repreſented in the *Moon's* Orb by WE and EH; therefore at the ſame Time, on the following Day, the *Moon* will be under the *Horizon* at H, at her riſing, and above the *Horizon* at F, at her ſetting the Day before: Where the Surface of the *Earth* muſt turn from A to B, and from D to C, before the *Moon* will be again in the *Horizon* at riſing or ſetting; which Motion from A to B, or from D to C, takes up above an Hour's Time more or leſs every Day. See *Fig.* XXI.

A. Sir, I thank you; I perfectly underſtand you, and the meaning of this *Phænomenon:* Pray hath the *Moon* any other Motion?

B. Yes: She revolves about her own Axis juſt in the ſame Time ſhe performs one Revolution about the *Earth*, viz. in 27 Days 7 Hours 43′.

A. Pray how are you ſure of that?

B. Becauſe at the ſame Times we always ſee the ſame Face or Side of the *Moon*; but this could not happen, unleſs a proper Motion about its Axis turned every Day juſt ſo much of the *Moon's* Body to the *Earth*, as her periodical Motion turns from it.

A. This muſt be a wonderful Harmony and Correſpondence of Motions, indeed! But what is the Form of the *Moon's* Orbit?

B. The *Moon's* Orbit is elliptical, but is perpetually changing, and never continueth the ſame Species, or of the ſame Figure.

A. How ſo, pray?

B. The Cauſe of the Inequalities of the Motions of the *Moon*, and the Form of her Orbit, is the different Attractions of the *Sun* and *Earth*, the Eccentricity of her Orb, and the Obliquity of the Axis of her daily Motion.

A. I think you agree the *Moon* receives all the Light ſhe ſhines with from the *Sun*.

B. Yes, ſhe does ſo; and by Reflexion conveys it to us in the *Sun's* Abſence.

A. Pray, *Sir*, give me leave to ask what is the Reaſon why ſome Parts of the *Moon's* Face look dark, and others light?

B. The bright Parts of the *Moon's* Body are the more eminent Parts of Land, which reflect the Light of the *Sun*, as Hills, Mountains, Promontories, Iſlands, *&c.* and the dark Parts of the *Moon* are thought to be Seas, Lakes, Rivers, Fens, *&c.* by ſome; and by others, they are ſaid to be ſhaded Valleys, Caverns, Pits, *&c.* But in Truth they repreſent both Water and ſhaded Places; for neither of theſe reflecting Light, muſt appear dark and not bright.

A. Then you ſuppoſe the *Moon* to be inhabited, I find; I have heard there be ſome of that Opinion.

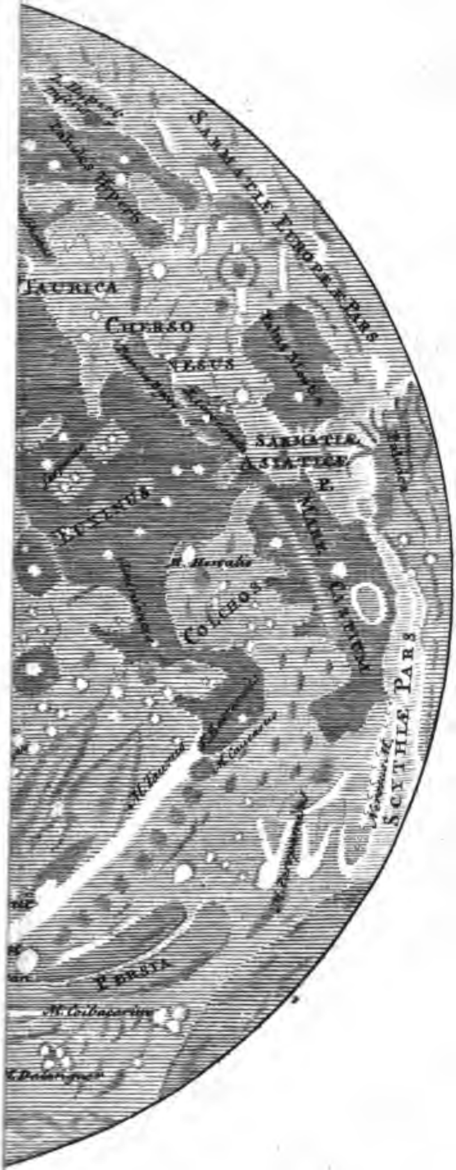
B. Yes, undoubtedly; to what End elſe can ſerve the Diſtribution of Land and Water, Mountains and Valleys, Caverns, Pits, *&c.*

&c. Beſides, an *Atmoſphere* of Air (and thereby Winds, Clouds, Rain, and other Meteors of Conſequence) has been lately diſcovered about it: No doubt but they ſerve the Purpoſes there as here, to nouriſh and ſuſtain Men, Beaſts, and Vegetables.

A. Indeed, if it be ſo, your Reaſoning and Inferences are very juſt: I wiſh I could have the Happineſs of viewing the Face of the *Moon* through a good *Teleſcope*, for my own Satisfaction.

B. 'Tis a very great Curioſity indeed; I can tell, becauſe I have thus viewed it many Times: I ſhould be glad if I had ſuch a Glaſs now, that I might gratify you in this Particular; however to make amends for that I can ſhew you the Face of the *Moon* curiouſly engraven, and juſt as it appears through ſuch a Glaſs, with the Names which ſeveral *Selenographiſts* have given to the ſeveral light and dark Parts thereof. See *Fig.* XX.

Fig IX.



Em: Bowen Sculpt

CHAP. IV.

Of Planetography, or the Philoſophy of the Planets.

A. PRAY what is the original Meaning of the Word *Planet*?

B. It is a *Greek* Word, and derived from the Verb Πλανάομαι, to *wander*, or *ſtray*; whence the *Engliſh* of this Word is, a *wandering Star*.

A. I think, I remember, you told me there were two Sorts of thoſe *Planets*, or *wandering Stars*; the firſt you called primary *Planets*, the other *Secondaries*, or *Moons*, or *Satellites*.

B. 'Tis true, I did; And the primary *Planets*, viz. *Mercury*, *Venus*, the *Earth*, *Mars*, *Jupiter*, and *Saturn*, are principally here intended, as the Subject of our preſent Diſcourſe; and the Secondaries we will only conſider amongſt the Accidents of the Primaries.

A. Well, ſince a *Planet* hath its Name from its Motion, we will firſt begin with the Motions of the *Planets*, if you pleaſe; And, pray, in what Order, Form, or Manner, do the *Planets* move?

B. I have already ſaid that the *Sun* is the Center of our Syſtem, about which the *Planets* all revolve in different Diſtances; firſt *Mercury*, 2 *Venus*, 3 *Earth*, 4 *Mars*, 5 *Jupiter*, and 6 *Saturn*, as you ſee them in the ſolar Syſtem; the Form of their Motion is elliptical more or leſs, and not perfectly circular; and they all move round the *Sun* in ſuch Manner as to deſcribe equal Areas of Space in equal Times.

A. Pray, *Sir*, if you can, illuſtrate this Matter by a Scheme.

B. *Sir*, that may be done very eaſily: Thus, let S be the *Sun*, ABPCD the elliptical Orb of a *Planet* P; then the Part of the Orb P is called the *Perihelium*, being the neareſt Diſtance from the *Sun*; and the Part A is called the *Aphelium*, as being the fartheſt Diſtance from the *Sun*; and SE is called the *Eccentricity* of the *Planet*; and as this *Eccentricity* is leſs or greater, ſo the Orb of the *Planet* is leſs or more elliptical, See *Fig*. XXII.

A. But you have not yet ſhewed what is meant by a *Planet's* deſcribing equal Areas in equal Times.

B. This is no more than to ſay, if the Times, in which the *Planet* moves in his Orb from P to C, and from C to D, and from D to A, be equal to each other, then the Areas, or Spaces PSC, CSD, and DSA (deſcribed in theſe equal Times, by Lines drawn from the *Planet* to the *Sun)* will alſo be equal among themſelves, and the contrary; do you apprehend me?

A. Yes, *Sir*, very plainly; for which I thank you: But, pray, why do you aſſign ſuch very unequal Portions of the Orbit to be paſſed over in equal Times? Do not the *Planets* move equal Diſtances in their Orbs in equal Times?

B. No, very far from it; for the Velocity of a *Planet's* Motion is different in every Part of its Orb, being ſometimes greater, and ſometimes leſs.

A. Pray how happens that?

B. By Gravity, or the *Sun's* Attraction: For, when the *Planet* is in P, the *Sun* attracteth it moſt ſtrongly; and therefore the Motion there, and there-abouts, is greater than any where elſe: Again, when the *Planet* is in its *Aphelium* at A, at its greateſt Diſtance from the *Sun*, it is then leaſt affected by the Power of Gravity, and conſequently the Motion there, and thereby, is the leaſt or ſloweſt of any Place in the Orb. But, when the Motion is ſo unequal, the Arches PC, CD, DA, muſt needs be ſo too, though deſcribed in equal Times.

A. Sir, I conceive it muſt be ſo now; I did not think of the *Sun's* Attraction: Since therefore thoſe Areas are always proportional to the Times; pray what Proportion of Gravity or Attraction will produce this?

B. The Power of Gravity is always reciprocally, as the Squares of the Diſtances of the *Planet* from the *Sun*: Thus, ſuppoſe the Diſtances SP, SC, SD, SA, were as the Numbers 5, 6, 9, 10, then the Power of Attraction in thoſe Diſtances would be reciprocally as their Squares, *viz.* 100, 81, 36, 25, ſo that it would be 4 Times greater in the *Perihelium* P, than in the *Aphelium* A; and this is the conſtant Law of all the *Planets* both primary and ſecondary.

A. Pray what other Affections are obſervable of the planetary Motions?

B. The *Planets*, as I told you, all move about the *Sun* in reality from *Weſt* to *Eaſt*; and yet they ſometimes appear to move the contrary Way, from *Eaſt* to *Weſt*, and ſometimes not to move at all for ſome Time; and thus they are ſaid to be direct, ſtationary, or retrograde.

A. I ſhould be glad if you could explain this to my Apprehenſion by a clear and eaſy Scheme.

B. That I will endeavour to do: Therefore, let S be the *Sun*, ACE the Orb of the *Earth*, and FGI a Part of the Orb of any one of the ſuperior *Planets*, ſuppoſe *Jupiter*; alſo let QR repreſent the Arch of the ſtarry Heavens, wherein we ſee and determine the Places and Motions of all the *Planets*: Now, ſuppoſe the angular Motion of the *Earth* be ſo much greater than that of *Jupiter*, that while the *Earth* deſcribes the Arch ECA, *Jupiter* ſhall only deſcribe the Arch HGF: Now conſider, that when the *Earth* is in E, the *Planet* at H will be ſeen amongſt the fixed Stars at M, and ſo he will alſo when the *Earth* is arrived to D; therefore all the Time the *Earth* is paſſing from E to D, the *Planet* will ſeem to ſtand ſtill about M, and is ſaid to be Stationary: Again, when the *Earth* is arrived to C, the *Planet* will really be moved forwards to G, but will be ſeen from the *Earth* at C, amongſt the Stars at N; wherefore while the *Earth* paſſeth *Eaſtward* from D to C, the *Planet* will appear to move *Weſtward* from M to N in the Heavens, which is backward; alſo, while the *Earth* moves from C to B, the *Planet* will ſtill ſeem to move backwards from N to O, where it will again be Stationary till the *Earth* comes to A: Do you underſtand me?

A. I believe I do: You mean that while the *Earth* paſſes from E to D, and from B to A, the *Planet Jupiter* will appear not to move in the Points M and O; and then he is ſaid to be Stationary: Alſo while the *Earth* is paſſing from D, by C, to B, and though *Jupiter* really moves in his Orb from H to F *Eaſtward*, yet he will ſeem to us to move from M to O *Weſtward*, or *Backwards*; and during that Time is ſaid to be Retrograde: I think this is the Matter as you intended I ſhould underſtand it; is it not?

B. Yes, I am glad to ſee you underſtand ſo great and ſtrange a Curioſity ſo compleatly; and in a like Way you may underſtand the ſame of the inferior *Planets*.

A. Pray what Particulars hath each *Planet*?

B. *Eclipſes* are particular to the *Earth*, *Jupiter*, and *Saturn*, becauſe thoſe *Planets* in particular have *Moons* or *Satellites* moving round them, which occaſion thoſe *Eclipſes*; alſo one Thing is particular or peculiar to *Saturn* alone, and that is a ſurpriſing Kind of a Ring, encircling the Body of this *Planet* at a great Diſtance. *Laſtly*, *Jupiter* hath the Appearance of Belts girding his Body; and *Jupiter*, *Mars*, and *Venus*, are found to have dark Spots on their Disks.

A. Well, that we may have ſome regular Account of thoſe wonderful Particulars, let me know firſt concerning the Nature, Number, and Diſtances, of the *Moons* or *Satellites* pertaining to the primary *Planets*.

B. The *Earth* hath one *Moon*, of which already; *Jupiter* hath 4 *Moons*, and *Saturn* 5 *Moons*: The Times in which they ſeverally revolve about their Primaries, and their Diſtances in Semi-diameters of the Bodies of *Jupiter* and *Saturn*, are as here follows:

In *Jupiter*.

	D.	H.	M.	Diſtance	Semid. of *Jupiter*.
1 *Satellite*	1	18	27	$5\frac{6}{10}$	
2 ———	3	13	13	9	
3 ———	7	3	42	$14\frac{3}{10}$	
4 ———	16	16	32	$25\frac{29}{100}$	

In *Saturn*.

	D.	H.	M.	Diſtance	Semid. of *Saturn*.
1 *Satellite*	1	21	18	$1\frac{9}{10}$	
2 ———	2	17	41	$2\frac{4}{10}$	
3 ———	4	12	25	$3\frac{4}{10}$	
4 ———	15	22	41	8	
5 ———	79	07	48	$23\frac{3}{10}$	

These *Moons*, and their *Affections*, were all diſcovered by Means of the *Teleſcope*; and before its Uſe, were unknown to the Ancients.

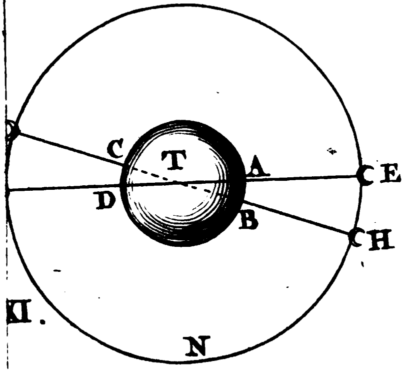
A. They are certainly noble Diſcoveries; but you ſay they are the Cauſe of *Eclipſes* to their Primaries; how, I pray you?

B. This, both in the primary, and alſo in the ſecondary *Planets*, will be beſt underſtood by a Scheme, ſhewing the *Eclipſes* of the *Earth* and *Moon*: For, in

Fig. XXIV, you obſerve the *Earth* E, in her annual Orb AB, moving about the *Sun*; at the ſame Time, you obſerve the *Moon* moving about the *Earth* in her Orb: Now when the *Moon* is in Conjunction with the *Sun*, i. e. when ſhe is juſt between the *Earth* and *Sun*, and is what we call the new *Moon*, as at M; then 'tis evident her Shadow will fall on the *Earth* at E, and conſequently will hide ſome Part of the *Sun's* Body from thoſe who dwell on that Spot; and this is what they call an *Eclipſe* of the *Sun*, but is properly an *Eclipſe* of the *Earth*; for you ſee 'tis the *Earth* that is really darkned, and not the *Sun*: Alſo 'tis evident, when the *Moon* is in the oppoſite Part of her Orb at N, in direct Oppoſition to the *Sun*, that then the *Earth* being exactly between the *Sun* and the *Moon*, will caſt her Shadow on the *Moon*; and the *Moon* being thus overwhelmed in the Shadow of the *Earth*, will appear dark or dusky, and is properly ſaid to be then eclipſed.

A. This, indeed, is ſo plain and evident by a bare Inſpection of that Figure, that I believe none can look on it, and not apprehend the Manner and Cauſe of *Eclipſes*. Pray can you tell the Quantity of *Eclipſes*?

B. Yes: The dark Shadow of the *Moon* covers a Part of the *Earth's* Surface, about



XI.

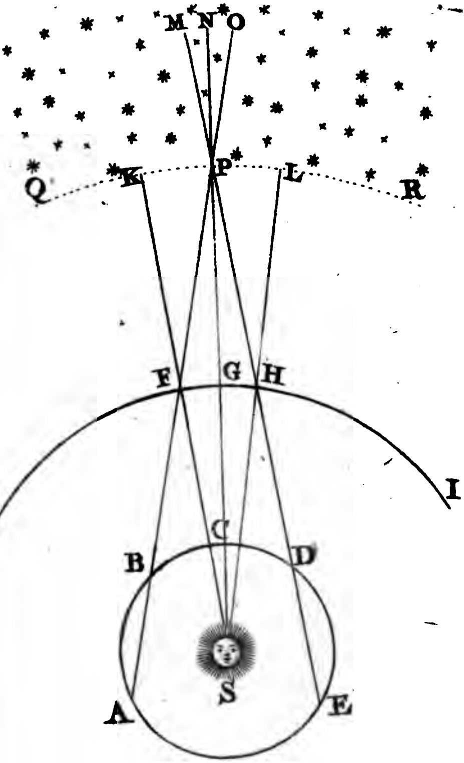


Fig: XXIII.

e. 126.

UNIV

180 Miles in Diameter, and moveth at the Rate of 2104 Miles an Hour: But the partial or penumbral Shadow, extends to the Wedth of 4900 Miles: And as to lunar *Eclipſes*, the Diameter of the *Earth's* Shadow at the *Moon*, is near 3 Times greater than the Diameter of the *Moon*; and therefore the *Moon*, in central *Eclipſes* of her Disk, is totally darkned, or eclipſed, for ſome Time.

A. So, I ſuppoſe, *Eclipſes* happen to *Saturn* and *Jupiter*, on account of their *Moons*; and likewiſe to the *Moons* themſelves, as well as to our *Moon*.

B. Yes; but the *Eclipſes* of thoſe *Planets* are much more frequent than of our *Earth*, the Number of *Moons*, and their quick Circulations, neceſſarily making them ſo; alſo the *Eclipſes* of thoſe *Moons* or *Satellites* are very frequent, one or the other being continually paſſing through the Shadow of their Primary.

A. Well, leaving the *Moons* and their *Eclipſes*; pray let me hear a Word or two about the wonderful Ring of *Saturn* that you mentioned juſt now.

B. This moſt ſurpriſing *Phænomenon* of all the viſible World, was firſt diſcovered about 100 Years ſince: It is of a prodigious Size, great Breadth, and vaſt Compaſs; it is ſaid the Diſtance of the inner Border of the Ring, from the Body of *Saturn*, is equal to the Breadth of the Ring it ſelf, each being computed to be at leaſt 21000 Miles; though others make the Interval between the Ring and *Saturn's* Body to be 210265, and the Breadth of the Ring to be 29200 Miles; its Thickneſs is unknown, as being too little for Obſervation; it hath a Variety of Aſpects, ſometimes appearing a larger *Ellipſis*, then a ſmaller; ſometimes only as a ſtrait Line, and ſometimes not viſible at all: Theſe are the moſt remarkable Particulars of this Prodigy of Nature known by us; as to the Matter of which it doth conſiſt, that is not known by any: I have here given you a Repreſentation thereof in *Fig.* XXV.

A. This is aſtoniſhing, and full of Wonder and Amazement indeed! But did not you ſay ſomewhat of a like Nature pertained alſo to *Jupiter*; pray what are thoſe Belts of his you mentioned but now?

B. Thoſe Belt-like Appearances of *Jupiter* are ſuppoſed to adhere to, or be in the Surface of his Body, and not at a Diſtance from it, as the Ring of *Saturn* is from him; they are 4 or 5 in Number, and appear as repreſented on *Jupiter's* Body in *Fig.* XXV.

A. And, pray, what are thoſe Belts ſuppoſed to be?

B. Some have imagined they are long Canals of ſome fluid Matter, or Water; and,

A PLANETS.

T	H.	VENUS.	MERCURY.
Their *Diameters* i	7964	7906	2460
The *Circumference*	5020	24823	7724
Their *Superficies* i	0205	196238000	1900804
Their *Solidity*, or	9070	258445900000	7793273000
Their *mean Diſtan*	000	59000000	32000000
The *Diameter* of	0000	118000000	64000000
The *Circumference*	9200	370636000	201024000
Their *periodical* Ti	. 9′.	224^{d}. 16^{h}. 49′	87^{d}. 23^{h}. 16′.
The *Times* of thei	. 56 .	0 . 23 . 00.	— — —
Their *daily mean*	. 08″.	01°. 36′. 08″.	04°. 05′. 32″.
The *Inclination* of	. 00 .	03 . 24 . 00 .	06 . 54 . 00 .
The *Excentricities*	—	517	7970
The *Proportion* of	435	— — —	— — —
The *Proportion* of	1000	985	30
The *Denſities* of t	400	— — —	— — —
The *Quantity* of	$\frac{59}{100}$	— — —	— — —
Their *Proportion* of	100	200	700
Their *Moons* or *Sa*	1	— — —	— — —

N. B. Th here ſtated in the *leaſt*

and, becauſe they have alſo obſerved ſeveral dark Spots on the Disk of *Jupiter*, they conclude his Surface is divided into Land and Water, as that of our Globe is; and is therefore inhabited; as they alſo ſuppoſe all other *Planets* are.

A. Then they imagine the *Planets* to be ſo many Earths, or peopled Worlds? But do not the different Diſtances of the *Planets* render that impoſſible, by occaſioning too great Light and Heat in ſome, and too great Cold and Darkneſs in others?

B. Their Bodies, with their ſeveral Organs of Senſe, are undoubtedly ſuited and adapted to the different Conſtitutions and Temperaments of the *Planets*, which are the Extremes, by the ſame almighty Power, and all-wiſe Providence, which hath ſuited our Bodies, *&c.* to the State of this *Planet* we live on, which is the mean.

A. What are the different Dimenſions, Revolutions, Denſities, Quantities of Matter, Light, Heat, *&c.* of the ſix primary *Planets*, we are diſcourſing of?

B. Theſe will be all ſeen to the beſt Advantage, and compared in one general View; to that End I have drawn up a Synopſis of them all together, as you here ſee, all grounded on Mr. *Whiſton*'s Calculations, which are the moſt moderate of any: I have moreover drawn the ſix primary *Pla-*

nets in their true Proportions of Magnitude in *Fig.* XXV.

A. *Sir*, 'Tis very good; I take it as a great Favour, and humbly thank you.

CHAP. V.

Of Cometography, or the Philoſophy of the Comets.

A. HAving thus pretty largely converſed with the *Planets*, and viewed their various Natures, Numbers, and Affections; let us next, if you pleaſe, diſcourſe of the *Comets*: And, in the firſt Place, pray tell me what the proper Meaning of the Word *Comet* is?

B. *Comet* is a *Greek* Word, derived of the Verb Κομάω, to have long Locks, or wear long diſhevelled Hair; becauſe a *Comet* ſeems to have as it were a long hairy Tail.

A. Pray what is the Matter or Subſtance of a *Comet*?

B. Sir *Iſaac Newton* ſaith the Bodies of *Comets*, or blazing *Stars*, are ſolid, compact, fixed, and durable Subſtances; and are, indeed, but a different Kind of *Planets*; which move about the Sun, and ſhine by the Light of the Sun-Beams reflected from them.

A. Pray how many Kinds of *Comets* are there?

B. Comets receive a Diviſion or Diſtinction on account of the different Form of their Tails: Thus,

Cometa Crinita, having a long Tail like a Horſe's.

Cometa Barbata, having a Tail like a long Beard.

Cometa Enſiformis, having a Tail like a Sword.

A. Why, *Sir*, do the *Comets* appear with blazing Tails, and no other Planet or Star do ſo?

B. This ſeems owing to ſome peculiar unctuous Matter in the Bodies of the *Comets*; which by their Approach to the *Sun's* Body is prodigiouſly heated, rarified, and made to fly off in a fiery Vapour, on that Side oppoſite to the Sun, in the Form of a long Tail, growing wider and thinner (as all fumy Vapours do) the farther it proceeds from the *Comet's* Body.

A. Then you ſuppoſe, I find, that the *Comets* revolve about the Sun, as well as the

Planets; but, pray, in what Kind of Orbs do they move?

B. They move, indeed, in ſtated Periods of Time about the Sun, in Orbs vaſtly eccentric and elliptical, but ſome more, and ſome leſs ſo, as their Periods are longer or ſhorter; the Form of three remarkable cometary Orbs you have deſcribed in the ſolar Syſtem beforegoing.

A. In what Parts or Regions of the Heavens do they move?

B. Far above our Atmoſphere, or Region of Air: Yet, when they come neareſt the Sun, they all deſcend within, or are not far above the Orb of *Saturn*; and thoſe which come neareſt to the Sun, are nearer than even *Mercury* it ſelf: Then from the Sun, they make amazing long Excurſions through the vaſtly diſtant Regions of the Univerſe all manner of Ways, and acroſs the Orbs of the Planets.

A. How far do you think ſome of the moſt erratick *Comets* may rove from the Sun?

B. Dr. *Halley* has determined the longer Axis of the Orb of that *Comet* (which appeared in 1680, and whoſe Period is 575 Years) to be 1382957 Parts, of which the mean Diſtance of the Earth from the Sun is 10000; wherefore ſuppoſing this mean Diſtance to be 81000000 *Engliſh* Miles, then the Length of that *Comet's* Orb will be 11201951700, *i. e.* above eleven thouſand and two hundred Millions of *Engliſh* Miles; which may be eſteemed as ſo far beyond the Sun, the Sun being, as it were, in the very Orb it ſelf at the hithermoſt End.

A. The *Comets* approaching thus near the Sun muſt ſurely be very Hot; and receeding again to ſuch a prodigious Diſtance, muſt there be again very Cold: Is it not thus, *Sir?*

B. Yes, moſt certainly: Sir *Iſaac Newton* has computed the Heat of the aforeſaid *Comet*, when neareſt the Sun, to be 3000 Times hotter than red hot Iron: But Bodies thus heated preſerve their Heat a long Time; 'tis computed that a Ball of Iron as big as the Globe of our Earth, would, if red Hot, require 50000, or fifty thouſand Years to grow cold in; but the Bodies of *Comets* being vaſtly greater than our Earth, can therefore never be cold, at their greateſt Diſtance from the Sun.

A. And, pray, can the Places of the *Comets* be found in the *Zodiac*, as thoſe of the *Planets*, by Calculation?

B. Yes: That indefatigable Improver of all Arts, Dr. *Edmund Halley*, has, by the Labour of many Years, compiled a Sett of Tables whereby the Places of above 20 *Comets* are to be determined for any given Time: A Work which will endure for ever;

and for which all future Aſtronomers muſt acknowledge themſelves indebted to this great Man.

A. Pray what do you farther obſerve concerning thoſe Bodies?

B. We may obſerve, that as they are diſcovered of late Years to be hard, ſolid Bodies, encompaſſed with an Atmoſphere, and revolve about the Sun in ſtated Periods of Time; that therefore they are a Part of the *Moſaick* Creation, as well as other Planets, and are not to be reckoned Meteors, caſually kindled and fleeting in the Air, as the ancient Philoſophers dreamed.

A. Well, to end the Diſcourſe of *Comets*; pray tell me in the laſt Place to what Uſe or Purpoſe they may ſerve?

B. Some conjecture they are appointed to demoliſh planetary old Worlds, and to ſupply Materials again for building them anew; others that they are ſo many Hells to puniſh the damned with perpetual Viciſſitudes of inolerable Heat and Cold; but all is uncertain.

CHAP.

CHAP. VI.

Aſtrography, or the Philoſophy of the fixed Stars.

A. PRAY do you not mean by *Aſtrography*, the Science or natural Knowledge we have of the fixed *Stars?*

B. Yes: It being compoſed of the *Greek* Words Αςρον, a *Star*, and Γραφὴ, a *Deſcription* (as hath been ſaid often before) whence it ſignifies a philoſophical *Deſcription* of the fixed *Stars.*

A. Pleaſe to tell me why they are called fixed *Stars?*

B. They are ſo called in Oppoſition to the *Planets*, or moving *Stars*; becauſe theſe always keep the ſame Place in the Heaven, and do not ſeem to move for many Ages together.

A. But by this, I think you imply they have ſome Motion.

B. The Motion of the fixed *Stars* is very ſmall, not exceeding 50″ of a Degree in a Year, or one Degree in 70 Years; and therefore to compleat one Revolution of a Circle is required 25920 Years, after which Time the *Stars* all return again to their former Places: This Period of Time they called the great, or Platonick Year, in ancient Times; and imagined when it was finiſhed, all Things would begin again anew, and return in the ſame Order they do now.

A. I underſtand by what you ſaid of the diurnal Rotation of the Earth, that the Motion of the *Stars* from *Eaſt* to *Weſt* each Night, is only an apparent one; but the Motion you ſpeak of now, I preſume, is a real and proper Motion of the *Stars*; is it not?

B. No, *Sir*, even this is not real, but apparent; being occaſioned by a certain contrary, equal Motion of the Earth, ariſing from the ſpheroidical Figure thereof, which Figure alſo ariſeth from the Rotation of the Earth about its Axis.

A. Thus much of the Motion of the fixed *Stars*; pray what do you think of their Number, is it not infinite?

B. Yes, for ought can be known, 'tis probable it is next to infinite; for with a good *Teleſcope* they appear Millions beyond Millions, 'till by their immenſe Diſtance they evade the Sight by the beſt Inſtruments; but then do not miſtake, thoſe which are viſible to your naked Eye, are (in the moſt ſerene Night) but a few, not above 3 or 4 Hundred.

A. No! That is a ſtrange Doctrine! Do not every Man's Eyes declare them innumerable? And doth not the Scripture alſo affirm the ſame?

B. I know People are not eaſily perſwaded to believe this new Notion of the Number of the *Stars* which are viſible, but it is founded on Demonſtration; the Eye is deceived by the vehement Twinkling, and confuſed Appearance of the *Stars*: And as to the Scripture, it ſpeaketh of the *Stars* hyperbolically, or elſe it meaneth the inviſible *Stars*, as well as thoſe that are viſible, and then, indeed, they are innumerable.

A. Pray how do you know the Number of the viſible *Stars* is ſo ſmall?

B. By aſtronomical Obſervations for many hundred Years paſt, and the Catalogues which have been ſeveral Times taken of them.

A. Catalogues! what, I pray you, of the *Stars*?

B. Yes, the fixed *Stars* have been long ſince regiſtered in the Records of Aſtronomy: *Hyparchus*, the *Rhodian*, about 120 Years before Chriſt, was the firſt who took a Catalogue of the *Stars*, his contained 1022: After him, *Ptolemy* enlarged this Catalogue to 1026: *Ulug Beighi*, the Grandfather of *Tamerlain the Great*, made a Catalogue of 1017 *Stars*: *Tycho* determined the Places of 777 fixed *Stars*, and reduced them to a Catalogue: *Kepler's* Catalogue contained 1163: The Prince of *Heſs's* Catalogue was of 400 *Stars*: The *Jeſuit Ricciolus* enlarged *Kepler's* Catalogue to 1468: 'Tis ſaid alſo that one *Bayerus* had deſcribed the Places of 1725: After this, *Heveling* of *Dantzick* compoſed a new Catalogue of 1888: But the largeſt and moſt compleat Catalogue ever yet publiſhed of the fixed *Stars* is that of Mr. *Flamſtead*, in his celeſtial Hiſtory, which contains three thouſand *Stars*; all whoſe Places and Situations are far better, and more exactly determined in the Heavens, than the Poſition of many Cities through which Travellers daily paſs.

A. Well, conſidering the many hundred of Years Obſervation on the *Stars*, and the various Catalogues made thereof which you have now related; and conſidering the moſt Compleat contains not above 3000 *Stars*, though aſſiſted by the longeſt and beſt Glaſſes, I am obliged to acknowledge my erroneous Notion of the great Number of the viſible ones; and ſhall next, if you pleaſe, ask your Opinion concerning their Diſtance from us?

B. Their Diſtance! Alas, you could hardly enquire about a Thing more unknown, or more incredible than what is but imperfectly known thereof; however to ſatisfy you, take the following Account: The famous *Hygens* found the brighteſt, and largeſt, and, of Courſe, the neareſt of all the fix'd *Stars*, viz. *Syrius*, to be in Appearance 27664 Times leſs than the Sun; and ſince their Diſtances are greater, as their Magnitudes are leſſer, therefore this *Star* muſt be at that Rate 2200000000000, *i. e.* above 2 Millions of Millions of *Engliſh* Miles; which is ſo very great, that a Cannon-Ball would ſpend almoſt 700000, *i. e.* ſeven hundred thouſand Years in paſſing through it; and it is very probable that all fixed *Stars* are equally diſtant from each other, in Proportion to the Diſtance of the neareſt of them from our Sun.

A. What is the Grounds of this your Opinion?

B. By the Smallneſs of their Appearance through the beſt Glaſſes, and the different Degrees thereof, I am induced to believe that they are not only as far diſtant from each other as from our Sun; but alſo that each fixed *Star* is a real Sun, ſurrounded by a Syſtem of *Planets* and *Comets*, and thoſe again furniſhed with different Numbers of Moons, all in the ſame Analogy, Order, and Proportions of Number, Size, and Glory, as we behold in thoſe of our own ſolar Syſtem.

A. O! amazing and ſtupendous Scene! Suns without Number; and Worlds turning up upon Worlds! Syſtems of moving Orbs immenſly great, yet inviſible to our Eyes; and all inhabited, diſperſed through all the diſtant Realms of univerſal Space! I am almoſt loſt, yea, quite confuſed in my Conceptions; but, pray, on what does ſuch a glorious *Hypotheſis* depend?

B. On Ratiocination, and divers aſtronomical Obſervations: We reaſon thus; our Sun ſhineth by its own native Light, ſo do the *Stars*; *ergo*, they are Suns: The Sun at the Diſtance of a fixed *Star* would appear no larger than a *Star*; *ergo*, &c. None of our Planets at that Diſtance could be ſeen at all; *ergo*, &c. God hath made nothing in vain (*Axiom* I) but nothing is more vain than to pretend Myriads of unſeen *Stars* were made to twinkle unheeded in the unſeen, unknown Regions of the Univerſe; *ergo*, &c. &c. &c. As to Obſervation, 'tis well known how *Stars* appear and diſappear after certain Intervals; what can this be but the Almighty's Hand extinguiſhing old, and kindling new Suns? Demoliſhing old, and erecting new Syſtems of Worlds? And ſuch undoubtedly was the Caſe of our World, and planetary Syſtem, in the *Moſaick* Creation. Our Sun juſt made, would have been a new fixed *Star* juſt appearing to an Eye in any of the neareſt *Stars*; ſome of our *Comets* alſo may there appear new *Stars*, when in their *Aphelia*, but in their Return to their *Perihelia*, diſappear again: Thus alſo ſome of our new *Stars* may be, and doubtleſs are, *Comets* (belonging to ſome Sun) in their utmoſt Excurſions, which, upon their Return, diſappear again: Theſe new and extinguiſhed *Stars*, are generally in the Galaxy, or Milky-way; but why there more than elſewhere, unleſs, becauſe thoſe Parts being repleniſhed with a far greater Number of Suns, give, of Courſe, more frequent Occaſions of theſe *Phænomena*? Alſo 'tis well known, that the Milky-way hath its Complexion from the united Luſtre of an infinite Number of fixed *Stars*, or *Suns*, in thoſe Parts of the Expanſe, which go by that Name: From all this conſidered, will any be ſo preſumptuous ſtill to deny ſo rational, evident, glaring, and glorious an Hypotheſis?

A. Sir, I believe ſcarce any but thoſe who are judicially blinded, and ſuffered to remain incorrigibly Ignorant, will ever pretend to heſitate about the Truth of this new and noble Doctrine; which ſo enlargeth our View of the wonderful Works of infinite Wiſdom, by putting the Univerſe into Signification and Harmony, and peopleing the ſame throughout with rational Beings: How will Poſterity bleſs the divine

Diſcoveries and Labours of theſe Ages, wherein the dark and barren Wilds and Deſerts of indefinite Space, have been enlightened by ſuch Millions of Suns; ſtored and planted with ſuch Myriads of Planets; and cultivated by ſuch endleſs Numbers of Inhabitants of every Kind?

THE

Philoſophical Grammar:

Or, VIEW of

Modern Philoſophy.

PART III.

AEROLOGY:

CONTAINING,

I. The Philoſophy of the *Atmoſphere*, or *Air*.
II. The Philoſophy of the *Winds*.
III. The Philoſophy of the *Meteors*.
IV. The Philoſophy of *celeſtial Appearances*.

Explaining what is hitherto known of their *Nature*, *Cauſes*, *Properties*, and *Effects*.

CHAP. I.

Of Aerology in general, or the Philoſophy of Air, ſhewing its wonderful Nature, Properties, and Effects.

A. PRAY, *Sir*, what is the original Signification of *Aerology?*

B. It is a Word compounded of Ἀὴρ, *Air*, and Λόγος, a *Diſcourſe*; and therefore imports a philoſophical *Diſcourſe* of the *Air*.

A. What are we to underſtand by *Air?*

B. That inviſible fluid Subſtance which encompaſſeth the Earth on every Side, which contains the Vapours, Clouds, and other Meteors, and which all living Creatures breath; and is in general called the *Atmoſphere.*

A. Pleaſe, *Sir*, to let me know why 'tis called the *Atmoſphere?*

B. From the two *Greek* Words, Ἀτμὸς, a *Vapour*, and Σφαῖρα, a *Sphere*; ſo that *Atmoſphere*, in native *Engliſh*, is a round Body of *Vapours*; and ſuch is the *Air* ſurrounding the Earth, as being conſtantly replete with *Vapours* exhaled by the Sun's Rays.

A. What are the principal Properties of the *Air?*

B. Theſe which follow: 1. The *Air* is fluid, yet cannot be congealed like Water. 2. It is Pellucid and Tranſparent to that Degree as to be inviſible. 3. It may be rarified and condenſed. 4. It is endued with an elaſtic Power or Force. 5. It hath Weight or Gravity. 6. It hath proper Bounds or Limits, and is not infinite. 7. It is neceſſary to Life, Flame, Sound, Light, *&c.*

A. Pray how can you tell the *Air* is a Fluid?

B. It hath all the Properties of a Fluid; is corporeal, heavy, its Parts yield to any Force impreſſed, and are eaſily moved one amongſt another; it preſſeth in Proportion to its Height, and the Preſſure is every way equal; 'tis evident therefore that it ought to be reckoned a Fluid.

A. What is the Reaſon the *Air* is ſo tranſparent, as to be inviſible?

B. Becauſe of the great Poroſity thereof; the Pores and Interſtices of *Air* being ſo very great and large, it admits the Light not only in right Lines, but in ſuch great and plentiful Rays, that the Brightneſs and univerſal Luſtre thereof, not only renders the *Air* Diaphanous, but entirely hinders the Opacity of the very ſmall Particles of *Air* from being at all ſeen; and therefore the whole Body of *Air* muſt conſequently be inviſible.

A. You obſerved next, the *Air* hath the Property of being rarified and condenſed; pray how is this demonſtrated?

B. That *Air* may be rarified is proved ſeveral Ways; as thus, if you take a Bladder, entirely empty as you think, and tie its Neck with a Thread, and lay it before the Fire, the Heat will ſo rarify the little incloſed *Air*, as to make it extend the Bladder to its utmoſt Stretch, and, if continued, will break through it with the Report of a Gun: Alſo, that *Air* may be ſo condenſed by Art as to take up but $\frac{1}{60}$ Part of the Space it poſſeſſed before, is proved by various Experiments.

A. Pray how do you prove the *Air*'s Elaſticity?

B. By various Experiments of the Air-pump, and otherwiſe: One very plain, is thus; an empty Bladder, whoſe Neck is faſt tied, being put into the Receiver, and the external *Air* therein exhauſted, the ſmall Matter of the incloſed *Air*, will by its own proper Spring, or elaſtick Force, gradually expand it ſelf, and at laſt will ſo extend the Bladder as to break it: Thus alſo, the *Air* compreſſed in the Wind-gun, will by its elaſtic Force (being diſcharged) drive a Bullet through a Board at the Diſtance of ſeveral Yards, in the ſame Manner as with Gun-powder: Yea, Mr. *Boyle* hath found that *Air* by its Spring, or Elaſticity, will ſo far dilate or expand it ſelf as to take up 13769 Times a greater Space than before: This Power of Elaſticity is as the Denſity of the *Air*.

A. Pray how do you become acquainted with the *Air*'s Gravity?

B. By Experiments of the Air-Pump, Barometer, *&c.* The Weight of the *Air* is greater, the nearer it is to the Earth's Surface: The *Mercury*, by the Preſſure of the *Air*, is raiſed in the Barometer to the Height of 28, 29, 30, or 31 Inches; therefore ſuch a Column of *Mercury* is equal in Weight to a Column of *Air* (of an equal Baſis) which proceeds from the *Mercury* in the Tub to the uppermoſt Part of the *Atmoſphere*: Alſo becauſe *Mercury* is about 14 Times heavier than Water, therefore Water will riſe in a Tube to 32 or 33 Feet in Height; and therefore every Square Foot in any Superficies ſuſtains the Weight of a Column of Water of 32 or 33 ſolid Feet; now a cubic Foot of Water weighs about 63 Pounds, hence the Weight of *Air* on every ſuperficial ſquare Foot, is above 2000 Pound Weight.

A. And, pray, what do you infer from thence?

B. Why, thence it appears, that if we allow the whole Surface of a Man's Body (of 6 Feet Stature) to be about 14 ſquare Feet, then the Weight of *Air* preſſing on the Body of ſuch a Man is equal to 28000 Pounds, or 250 hundred Weight; that is 12½ Tun: Alſo, ſince the Number of ſquare Miles on the Earth's Superficies is computed 199250205, and in one ſquare Mile are 27878400 ſquare Feet, the ſquare Feet on the Earth's Superficies will be ſomewhat above 5547800000000000; whence the Weight of the whole *Atmoſphere*, or its Preſſure on the Superficies of the whole Earth, is more than 11095600000000000000 Pounds, or much about 5000000000000000 Tuns; that is, the *Atmoſphere* compreſſeth the Earth with a Force, or Power, nearly equal to that of five thouſand Millions of Millions of Tuns.

A. This is extreamly wonderful! But, pray, how happens it that Men, Beaſts, Houſes, &c. are not cruſhed to Pieces, if they are preſſed with ſuch an intolerable Weight of *Air*?

B. By the Equilibrium of the internal *Air*, or the *Air* within all Bodies; which though it be ſmall, and not worth naming, yet, can ballance, reſiſt, and equiponderate the Force of the external *Air* (as is proved by various Experiments) how great a Quantity ſoever it be: The Experiments of the Air-pump which confirm this are very ſurprizing.

A. I think, *Sir*, all you have ſaid of the Weight and Gravity of the *Atmoſphere*, or *Air*, is full of Aſtoniſhment; and, pray, can you tell any Thing of the Height of it?

B. Nothing certainly can be determined about that, becauſe the higher you go, the rarer the *Air* is; and there being no certain Means to determine in what Proportion the *Air* becomes rarer and rarer through the whole Extent thereof, there can of Courſe be no preciſe Account of its Altitude; However, they compute the *Air* at the Height of 42 Miles, to be 4096 Times more rare, or thin, than with us; and this being next to nothing, the Height of the *Air* may be reckoned about 40, or 45 Miles agreeably hereto: Dr. *Keil* hath calculated its Height to be 44 Miles by an Obſervation of the Twilight.

A. Pray what other very remarkable Properties hath the *Air?*

B. It is not only the Means, but as it were the Matter of Life itſelf, and therefore abſolutely neceſſary.

A. How do you ſhew it to be the Means of Life?

B. By putting certain Animals into the exhauſted Receiver; where it is ſurpriſing to ſee the Effects of withdrawing the *Air* by the Pump on the Bodies of thoſe Creatures: You will thus ſee Dogs, Cats, Rats, Mice, *&c.* turn up and expire in half a Minute, and look as thin as a Rag: A Mole dieth in one Minute: Inſects, as Waſps, Bees, Hornets, Graſhoppers, *&c.* in two Minutes ſeem dead; and will continue a whole Day and Night without *Air*, and afterwards revive in open *Air:* Earwigs, Beetles, Snails, *&c.* endure the Air-pump prodigiouſly; and Frogs will longer preſerve their Lives in Vacuo than Toads; yea, thoſe inviſible Animalcules in Pepper-water, will revive in the open *Air*, after having lain 24 Hours in Vacuo.

A. It muſt be curious, indeed, to ſee thoſe artificial Deaths and Reſurrections in dumb Creatures! But, pray, how do you underſtand *Air* to be the Matter of Life?

B. 'Tis certain *Air* is impregnated with a vivifying Spirit, or Matter, which is immemediately neceſſary to Life; and that this vivifying Spirit is inflammable, or proper to feed Fire, and capable of being burnt or conſumed thereby; for it is known by Experiment that no Creature will live, nor a Candle burn, in *Air* which hath paſſed through the Fire, and may be called aduſt or burnt *Air*.

A. Is the *Air* alſo of ſervice to Vegetables and Plants?

B. Yes, in as much as there is a manifeſt Reſpiration in Plants and Trees, on which their vegetable Life depends, and is preſerved; this is known by numberleſs Experiments.

A. Hath not *Air* an Effect on Bodies which tends to diſſolve them?

B. Yes, the *Air* hath the Faculty of a Menſtruum, or a Power of diſſolving Bodies: It will reduce Chryſtal-Glaſſes to a Powder in Time; ſo divers Minerals, Earths, Stones, Foſſil-Shells, Wood, &c. which, perhaps, from *Noah's* Flood, have lain under Ground ſecure from Corruption, yet, being expoſed to the corroſive Quality of the *Air*, have ſoon mouldered away; ſo Iron, Steel, Copper, &c. may be ſoon diſſolved into a Ruſt, &c. But ſuch Things are too common to be inſiſted on, or to want Proof.

A. I have heard you make out already how *Air* is the Means of Sound; but, pray, what Advantages of Light and Sight accrue thereby?

B. Very great (perhaps, greater than you may be yet appriſed of) are the Benefits and Advantages of the circumambient *Air* in theſe Regards: For *firſt*, were it not for the Refraction of the *Atmoſphere*, the Heavens by Day would have the Appearance of Night; the Stars, even the ſmalleſt, would appear and twinkle; the Sun, indeed, would appear a great Light in that Part of the dark Firmament where it was; but ſhould a Spectator turn his Back to him, he would ſee all Night and Darkneſs ſurround him at Noon-tide. *Secondly*, The Sun at riſing and ſetting would have the ſame Brightneſs and Luſtre as at Noon-day, and ſo would be hurtful to our Eyes. *Thirdly*, As ſoon as the Sun deſcended the Horizon, we ſhould be in total Darkneſs, and a cloudy Night would then preſent us with the blackeſt Darkneſs poſſible. *Fourthly*, As we ſhould have no Twilight by Night, nor ſhining Luſtre of the Firmament by Day, ſo we ſhould want that Advantage we now enjoy, of not only being bleſſed with the Light of the Sun when abſent, but even of the actual Appearance of the Body of the Sun himſelf, each Day, before he riſeth and after he ſetteth.

A. What, I beſeech you, *Sir*, do you ſuppoſe we can ſee the Sun when he is really under the Horizon?

B. Yes, we do, for the Space of ſome Minutes each Day.

A. Pray, *Sir*, if poſſible, let me underſtand how this can be by a Scheme?

B. I will, and you may very eaſily apprehend the Truth of this Aſſertion (tho' ſtrange) from thence, provided you remember what I ſaid of the Reflection and Refraction of Light when we diſcourſed on that Subject.

A. I do remember it very well, pray proceed.

B. Then pleaſe to caſt your Eyes on *Fig.* XXVI, which repreſents the Earth ſurrounded by its *Atmoſphere:* Now let HO be the Horizon of a Perſon at P, S is the Sun really under the Horizon, from which a Ray of Light SI proceeds, and falls on the upper Part of the *Atmoſphere* at I; this Ray by the thicker Medium of the *Air* is bent from its direct Courſe to D, into the oblique one IP, and ſo ſtriketh the Spectator's Eye; the Spectator then will ſee the Sun in the Direction of this refracted Ray PI, *viz.* at R, which is above the Horizon: And thus at ſome Times of the Year, we ſee the Sun above the Horizon near 10 Minutes whilſt it is really below it on one Day, taking the Mornn.

Fig: XXV.

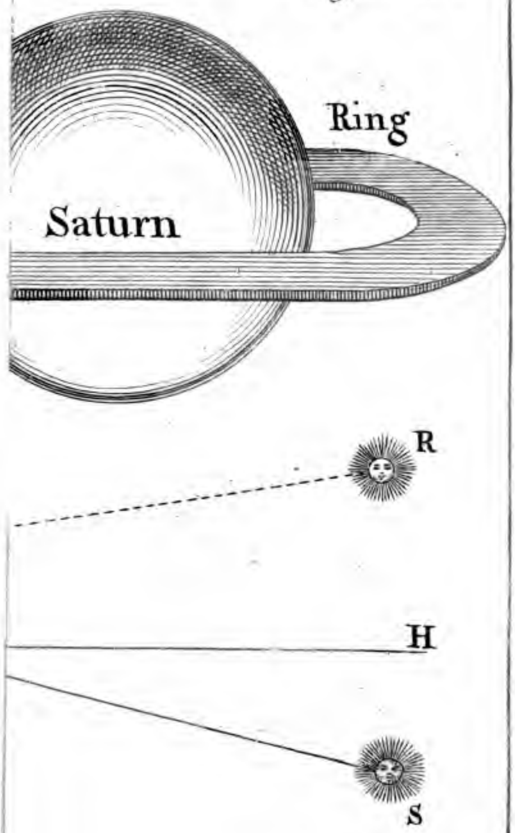


Plate VI. Page 154

UNIV O MI

Morning and Evening together; at a Medium it is 6′ ⅓ each Day throughout the Year, which is as good as 3 ¼ equinoctial Days in one Year; which is almoſt a whole Year's ſhining Sun in a Century more than we could otherwiſe have had.

A. Sir, I perceive it very plainly, and give you abundance of Thanks.

CHAP. II.

Anemography, or the Philoſophy of the Winds.

A. HOW do you derive the Word *Anemography*?

B. From the two *Greek* Words Ανεμος, *Wind*, and Γραφὴ, a *Deſcription*; it therefore ſignifies a philoſophical *Deſcription* of *Winds* in general.

A. Pray, *Sir*, what is the *Wind*?

B. Wind is nothing but a Stream or Torrent of Air, as a River is a Stream or Torrent of Water.

A. What Diſtinction, I pray, do the Philoſophers make of the *Wind*?

B. My Lord *Bacon* diſtinguiſheth *Winds* into four Kinds, *viz.*

1. General *Winds*, which always blow from the ſame Quarter.
2. Stated *Winds*, which blow only certain Seaſons from the ſame Point.
3. Servile *Winds*, which regard the Region, Time, Seaſon, *&c.*
4. Liberal *Winds*, which blow indifferently any where, or any how.

But this is not ſo natural as the following Diviſion of *Winds*, viz.

1. General, or coaſting Trade *Winds*.
2. Periodical, or ſhifting Trade *Winds*, called *Monſoons*.
3. Common, or caſual *Winds*, the ſame as the foregoing liberal *Winds*.

A. What are the different Qualities of *Wind*?

B. They differ (ſaith my Lord *Bacon*) not much more in the Points from which they blow, than in the Qualities with which they are diverſified; for ſome are violent, other gentle; ſome are cold, others hot; ſome are conſtant, others mutable; ſome moiſten and diſſolve, others dry and thicken; ſome gather Rain, others are tempeſtuous and diſpel it; and others are ſerene and ſmooth.

A. Pray what are the Cauſes of *Wind?*

B. Any Thing that can deſtroy the Equilibrium of the Air, and by acting on ſome Part with a greater Force, putteth it into an Agitation, produceth ſuch a Stream or Current of Air, as we call *Wind.*

A. This is ſo very general an Aſſignation, as gives me but little more Notion of the Thing than I had before.

B. In all Caſes we cannot be acquainted with Particulars; however, 'tis pretty certain that divers Things, as Eruptions of Vapours from Sea or Land, Rarefactions and Condenſations in particular Places, the Fall of Rains, Preſſure of Clouds, *&c.* may alter the Equipoiſe, or Ballance, of the *Atmoſphere*; and thereby cauſe *Winds* more or leſs: Beſides, ſeveral Caves, and ſome great Lakes, emit or ſend forth *Winds*; but the moſt general Cauſes of *Wind* are from Heat and Cold, as is manifeſt from the general and periodical Trade *Winds* between the Tropicks, and thereabouts.

A. Pray what are thoſe *Winds* you call general Trade *Winds?*

B. Such as blow conſtantly all the Year long from one Quarter; as from the NE, or about the *North-Eaſt*, on the *North-Side* of the Equator to 30 Degrees Latitude; and from the SE, or about the *South-Eaſt*, on the *South-Side* of the Equator to about 30 Degrees Latitude, in the *Atlantick*

Ocean, *Ethiopean* Sea, the *Indian* Ocean, and great *South-Sea*: Theſe *Winds*, for your better conceiving them, I have repreſented in the Map adjoined, by dark Lines in the aforeſaid *Atlantick*, *Ethiopick*, and *Indian* Seas; in which you will ſee divers Arrows ſhewing the Courſe of thoſe *Winds*.

A. This, *Sir*, is very helpful and improving, and maketh the Thing eaſier than your very Words can do: But, *Sir*, doth the *Wind* blow conſtantly in thoſe various Courſes and Directions, ſhewn by the Arrows, within a ſmall Diſtance of the Coaſts of *Africa Weſtward*?

B. Yes; they are called the general coaſting Trade *Winds*, and always blow on the Points the Arrows ſhew.

A. But, pray, what is the Meaning that I ſee in the Map ſeveral Arrows in clear void Spaces, ſome pointing one Way, and others the contrary quite, with the Names of the Month abreviated fixed to them?

B. I will inform you: It is in the *Arabian* Sea, the Bay of *Bengal*, the *Chineſe* Seas, by the *Eaſtern* Coaſts of *Africk*, and to 10 Degrees of *South* Latitude in the *Indian* Ocean, that you find thoſe contrary Arrows; and in thoſe Parts you muſt know the *Wind* blows one half of the Year one Way, and the other half the contrary Way: Theſe are called the periodical or ſhifting

Trade *Winds*, which the Sailors call the *Monſoons.*

A. Then, I ſuppoſe, as the Arrows in thoſe ſeveral Places ſhew the various Courſes of the *Monſoons*, ſo their Times of ſhifting or changing their Points, are denoted by the Names of the Months affixed thereto.

B. Yes, they are, you underſtand the Matter very well; and therefore all thoſe who ſail in theſe Seas, are obliged to obſerve the Seaſons proper for their Voyages, and in ſo doing they fail not of a fair *Wind*, and ſpeedy Paſſage.

A. How do you account for ſome *Winds* blowing always one Way, and others on contrary Points, in equal Periods of Time?

B. The moſt ſagacious Dr. *Halley* (the Author of all the preſent Philoſophy of *Wind*) gives this Account thereof, *viz.* That, according to the Laws of Staticks, the Air which is leſs rarified and expanded by Heat of the Sun's Beams, and conſequently more ponderous, muſt have a Motion towards thoſe Parts thereof, which are more rarified, and leſs ponderous, to bring it to an Equilibrium, or Ballance. And, 2. That the Preſence of the Sun continually ſhifting to the *Weſtward*, that Part towards which the Air tends, by Reaſon of the Rarefication made by his greateſt meridian Heat, is with him carried *Weſtward*; and conſequently, the Tendency of the whole Body of the lower Air is that Way: And thus a general *Eaſt-Wind*, is formed in the *Atlantick* and great *South* Sea, perpetually blowing *Weſtward*.

A. But, I obſerve, by the Arrows, thoſe *Winds* decline from the *Eaſt*, *Northward*, on the *North* of the Equator, and *Southward*, on the *South-Side*: Pray how happens that?

B. Becauſe near the Line, the Air is much more rarified than at a greater Diſtance from it *Northward* and *Southward*; wherefore the Air being towards thoſe diſtant Parts leſs rarified than in the Middle, will conſequently tend from the *North* and *South* to the Equator, and ſo become NE and SE *Winds*.

A. But, pray, why are not thoſe *Winds* as univerſal in the *Arabian*, *Indian*, and *Chineſe* Seas, and other Parts between the *Tropicks*, which have the ſame Situation to the Sun, as the *Atlantick*, *Ethiopick*, or great *South* Ocean?

B. The Reaſon hereof is, undoubtedly, owing to the Circumpoſition of ſuch great Continents, which break the Continuity of the Oceans; and from the Nature of their Soil, and the Poſition of high Mountains, produce thoſe ſeveral Variations of the *Wind* in thoſe Places: Thus, the *Winds* ſet in upon the Land, even from *Weſtward*, on ſome Parts of *Guinea*; becauſe the Soil being ſandy, reflects prodigious Heat, which greatly rarifies the Air, and maketh the more cold, and denſe, tend thither from the *Weſtern* Sea, to reſtore the Equilibrium.

A. And, pray, how is the ſudden Change of the *Wind*, to oppoſite Points, accounted for in the periodical *Winds*, called the *Monſoons*?

B. Thus: The cold and denſe Air, by Reaſon of its greater Gravity, preſſes upon the hot and rarified; and therefore the rarified Air muſt aſcend in continued Streams as faſt as it rarifies, and being aſcended, it muſt diſperſe it ſelf to preſerve the Equilibrium; and thus, by a contrary Current, the upper Air muſt move from thoſe Parts where the greateſt Heat is, and ſo, by a Kind of Circulation, the NE Trade *Wind* below will be attended with a SW *Wind* above, and the SE with a NW above: Now becauſe the Air coming out of the NE, over vaſt Continents of Land (which when the Sun is *Northward*, are intolerably hot; but more cold and temperate, when the Sun is at the *Southern Tropick*) into the *Indian* Sea, is ſometimes hotter, and ſometimes colder, than that whereby this Circulation is returned out of the SW; by Conſequence, the under Current of

Air is one while from the NE, and other while from the SW.

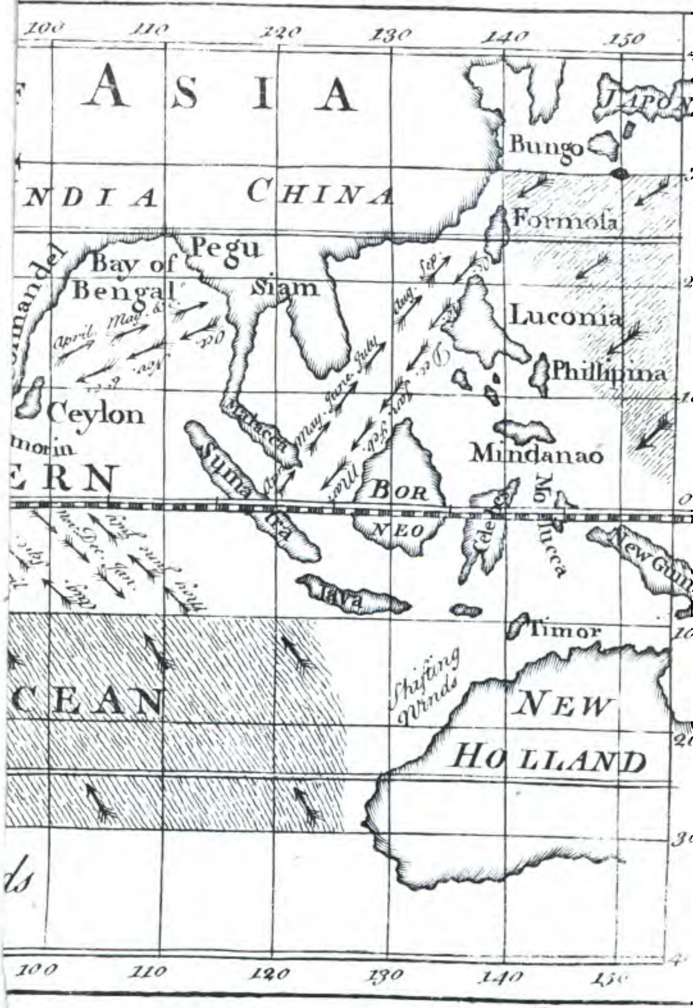
A. Do not the Seaſons help to determine ſomewhat of this Matter, in which thoſe Changes happen?

B. Yes, they plainly confirm what I have before ſaid; for in *April*, when the Sun begins to warm thoſe Countries to the *North*, the SW *Monſoons* begin, and blow during the Heats 'till *October*; when the Sun being retired, and all Things growing cooler *Northward*, and the Heat encreaſing to the *South*, the NE *Winds* enter, and blow 'till *April* again: But yet, why the *Monſoons* change here, and not in the *Ethiopick* Ocean; and alſo why the Limits of the Trade *Winds* are fixed to about 30 Degrees of N and S Latitude, is not ſo well to be accounted for; and therefore muſt be left, with ſeveral other Intricacies of this Nature, to the Diſquiſition and Diſcovery of ſucceeding Ages.

A. Well, ſo much then for general and periodical Trade *Winds*; pray have you any Thing farther to obſerve of the common and variable *Winds*, incident to all Points and Places?

B. Yes, a few Things touching their Qualities, Velocities, and Extent or Limits.

oons or Shifting Trade Wind



Bowen sculp

A. Pray what do you obſerve of their Qualities?

B. That thoſe *Winds* are dry and cold, which contain the leaſt Quantities of Vapours; thoſe *Winds* gather and generate Clouds, which carry with them great Quantities of Vapours; thoſe *Winds* are hot, which blow from off hot Regions; and cold, which blow from cold ones; thoſe are the moſt violent which are agitated by the greateſt Force, and the contrary.

A. And, pray, what is diſcovered of the Velocity of *Wind*?

B. It is found by Experience, that the Velocity of *Wind*, in a great Storm, is not more than 50 or 60 Miles an Hour; and that a common brisk *Wind* moves 15 Miles an Hour; and ſome are ſo ſlow as not to move 1 Mile an Hour.

A. In the laſt Place, what do you obſerve of the Extent, or Limits, of the *Wind*?

B. That it is very uncertain, and little known, unleſs of the aforeſaid Trade *Winds*: The moſt we know of common *Winds* is their Uſe, in cooling and cleanſing the Air from all poiſonous Contagions, and peſtilential Exhalations; and thereby keeping it always pleaſant, pure, and ſalutiferous, or healthful; whence appears their abſolute Neceſſity to animal Life, and Conſervation of the Univerſe.

CHAP. III.

Meteorography, or the Philoſophy of Meteors in general, viz. *Vapours, Fogs, Miſts, Clouds, Rain, Hail, Snow, Froſt, Ice, Thunder, Lightening, Ignis Fatuus, or Jack in a Lanthorn, Flying Dragons, and ſuch like.*

A. I Pleaſe my ſelf with the Thoughts of converſing on Subjects now, very pleaſant and curious, ſuch as what you call the Doctrine of *Meteorography* ; but, before we proceed, pray let me know what is the true and proper Meaning of the Word *Meteor* ?

B. The *Greek* Word Μετέωρον, *Meteoron*, is compoſed of *μετα*, *beyond*, and *ἀείρω*, *to lift up aloft* ; and therefore a *Meteor* implies that which is elevated aloft beyond us in the Air, as *Clouds*, *Lightening*, &c.

A. Pray how many Kinds of *Meteors* do you reckon ?

B. Some diſtinguiſh them into three Sorts, fiery, airy, and watery.

A. Which do they call fiery *Meteors* ?

B. Such as are compoſed of a fat ſulphurous Exhalation, kindled by the nitrous

Quality or Subſtance of the Air; and do then exhibit the Appearance of Light and Fire in the Air, as *Lightening*, *Flying Dragons*, &c.

A. What are thoſe called airy *Meteors?*

B. The Wind, and its divers Kinds; but, properly ſpeaking, the Wind is no *Meteor* at all, nor are there any *Meteors* which conſiſt merely or principally of Wind.

A. Pleaſe to recount me thoſe you call watery *Meteors?*

B. They are ſuch as conſiſt of *Vapours*, and watery Particles, which are ſeparated from one another, and raiſed by the Sun's Heat, and become modified in the Air into various Forms, as *Miſts*, *Clouds*, *Rain*, &c. in abundance.

A. Which do you hold it will be moſt natural to begin a Converſation withal, of thoſe ſeveral Sorts of *Meteors?*

B. It will certainly be moſt natural to begin with watery *Meteors.*

A. Well then, to make a Beginning, I obſerve you ſaid thoſe *Meteors* originally conſiſt of *Vapours*; pray what are they?

B. *Vapours* are a Company of aqueous Particles, ſeparated from the Surface of the Water, or moiſt Earth, by the Action of the Sun's Heat; whereby they are ſo far rarified, attenuated, and ſeparated from each other, as to become ſpecifically lighter

than

than the Air, and conſequently, they riſe and float therein; and thus, any Kind of Heat, or Fire, may cauſe *Vapours.*

A. Pray what *Meteors* are immediately formed of *Vapours?*

B. Fogs, and *Miſts*: *Fogs* are thoſe Collections of *Vapours* which chiefly riſe from fenny, moiſt Places, which become more viſible as the Light of the Day decreaſeth; if theſe are not diſſipated, but unite with thoſe that riſe from Waters, as Rivers, Lakes, &c. ſo as to fill all the Air in general, then they are called *Miſts*; and often they ſtink from a ſulphureous Exhalation, or Matter, they contain.

A. Pray what *Meteors* are next formed of *Vapours?*

B. Clouds are the next State of *Vapours*; for they conſiſt only of a Congeries of *Vapours* exhaled from Sea and Land, and raiſed to that Height in the Air, where they become of equal Weight, or Gravity, with the Air; in thoſe Parts therefore, they float and ſwim, and by ſtriking one againſt another, and mixing one with another, they coaleſce, or thicken, and become more denſe and weighty; the thiner or rarer the *Clouds* are, the lighter and higher they ſoar; but the more denſe they are, the weightier, and the nearer they ride to the Earth.

A. Pray how high do you judge the *Clouds* to fly?

B. From about a quarter of a Mile to a Mile; 'tis very common for Perſons, by climbing very high Mountains, to get above the *Clouds*, and ſee them ſwim beneath them, cleaving againſt the Mountain they are on.

A. That muſt be very curious to obſerve; but, pray, whence the various Figures and Colours of the *Clouds*?

B. The wonderful Variety in the Colours of the *Clouds*, is owing to their particular Situation to the Sun, and the different Reflections of his Light: The various Figure of the *Clouds* reſults from the looſe and voluble Texture of their Compages, revolving into any Form, according to the different Force of the Winds.

A. That Rain is produced from the *Clouds* we all know; but, pray, in what formal Manner doth it happen?

B. Thus: When various Congeries of *Clouds* are driven together by the Agitation of the Winds, they mix and run into one Body, and thus diſſolve and condenſe each other into their former Subſtance of Water; alſo the Coldneſs of the Air, is a great Means to collect, compact and condenſe *Clouds* into Water: The Water thus produced of the *Clouds*, being heavier than Air,

muſt

muſt of Neceſſity fall through it in the Form we call Rain.

A. But, pray, why does it fall in Drops, and not in whole Quantities, as it becomes condenſed in the Air?

B. So it would fall in great Quantities, were it not for the Reſiſtance of the Air; but the Subſtance of the Air breaketh and divideth it into Parts, ſmaller and ſmaller, the farther it paſſeth through it, 'till at laſt, it arrives to us in very ſmall Drops.

A. Pray is not *Dew* a Kind of *Rain?*

B. Yes; only with this Difference, that whereas *Rain* falls at any Time, and in great Drops; *Dew* falls only at ſtated Times, and in ſuch very ſmall and fine Drops, that they are ſcarcely viſible, 'till they are fallen and condenſed into Drops on the Tops of Graſs, Boughs, &c.

A. In the next Place, pray, *Sir*, explain how the *Meteor*, we call *Snow*, is produced?

B. Snow is produced thus: When the *Vapours* are become conſiderably condenſed, yet not ſo far as to become liquefied, or diſſolved into Water, then, by a ſpecial Degree of Coldneſs in the upper Air, the Particles of the condenſed *Vapours* are compelled into a hard, rigid, and glacy Subſtance, ſeveral of which adhering together, form little Fleeces of a white Subſtance ſomewhat heavier than the Air; and therefore deſcend in a ſlow and gentle Manner through it, being ſubject, by its Lightneſs, to all the various Motions of the Air and Wind; and is what, when arrived to us, we call *Snow.*

A. And, pray, is not *Hail* formed after ſomewhat a like Manner?

B. *Hail* is thus generated: When the *Cloud* which raineth is very high in the Air, or when all the Regions of the Air are very cold, the falling Drops of Water are congealed thereby, and grow into a glacy Subſtance ſomewhat white and hard, of different Size and Figure, according to the Particles of Water, the Degrees of Heat and Cold, the Wind, *&c.* and this, when come to us, we call *Hail.*

A. Although, I ſuppoſe, you do not reckon *Froſt* and *Ice* among *Meteors*, yet I believe this may be as proper a Place to diſcourſe of them as any; and therefore, if you pleaſe, be ſo good as to explain to me their Natures?

B. Dr. *Cheyne* ſaith, that *Cold* and *Freezing* ſeems to proceed from a ſaline or ſalt Subſtance floating in the Air, whoſe Particles are very ſharp and pointed, and theſe inſinuating themſelves (in a wedge-like Manner) into the Pores of the Particles of Water, do thereby fix, chryſtalize, and make hard the ſuperficial Parts of Water, and all humid Subſtances; and hence the incruſtated Surface of Earth, Dews, &c. we call *Froſt*, and the fixed and chryſtalized Superficies of Water, we call *Ice*: But, when the Heat of the Sun diſſolves thoſe freezing, ſaline Particles into a Fluid, the Surface of the Water, &c. all return to their former natural State; and this we call *Thawing*.

A. Have you any Thing farther to conſider, as watery *Meteors*?

B. No, thoſe now deſcribed are the whole Tribe; and as we have already largely ſcanned the Nature of the Wind, which ſome (as I told you) improperly make a ſecond Sort of *Meteors*, let us now paſs to the Speculation of thoſe which are called fiery *Meteors*.

A. With a very good Will, *Sir*; nothing delights me ſo much as thoſe Kinds of natural Reſearches; and in the firſt Place, pray which do you count the Principal of all the fiery *Meteors*?

B. *Lightening*, which is thus occaſioned: The Air doth abound with Steams and Exhalations of Sulphur, Bitumen, Nitre, and Salts of various Sorts, Acids, and Alkalies; theſe being raiſed by the Sun's Heat into the higher Regions of Air, are there diſperſed and ventilated to and fro by the Winds; this Agitation produces a Mixture, and conſequently, a Fermentation of thoſe combuſtible Sulphurs with the nitrous Acids, which is often to that Degree as to kindle into Flame, and thereby cauſe thoſe ſhining Flaſhes of *Lightening* we ſee darting from the Sky.

A. But, pray, *Sir*, what makes the *Thunder* with it?

B. *Thunder* is occaſioned by the kindling thoſe bituminous, and ſulphureous Exhalations in the Air by the nitrous Salts, in the ſame Manner as the Exploſion is produced by ſetting Fire to Gun-powder, or Aurum Fulminans; and the Reaſon why we do not hear the dreadful Fragor or Noiſe of *Thunder*, ſo ſoon as we ſee the *Inflammation* or *Lightening*, is becauſe Sound is longer arriving to our Ears, than Light to our Eyes; as I have before told you.

A. I have heard talk of *Thunder-Bolts*, and their ſtrange Effects; pray what do Philoſophers ſay of it?

B. What is called a *Thunder-Bolt*, is nothing but a more ſolid, and moſt rapid Flame, which, with incredible Celerity, flies from the *Clouds* to the Earth, and through every Thing ſtanding in the Way, being interrupted by nothing. The more remarkable *Phænomena* of which are as follow: 1. That it affects high Places chiefly, as Mountains, Towers, Trees, *&c.* 2. That it will ſometimes burn a Perſon's Clothes, while his Body remains unhurt. 3. That, on the contrary, it will ſometimes break a Man's Bones, while his Clothes and Fleſh receive no harm. And 4. In like Manner, it will ſometimes melt or break the Blade of a Sword in the Scabbard, while the Scabbard remains untouched; and, on the contrary, will ſometimes burn the Sheath, and not affect the Sword. The Reaſon of theſe ſtrange and contrary Effects Philoſophers can but conjecture at, imputing it to the different Figure and Quality of the Particles of *Lightening*, which renders them capable of diſſolving ſome Subſtances, at the ſame Time, that it will not touch others.

A. All this is very ſtrange indeed; pray what other fiery *Meteors* are remarkable?

B. The ſame aerial Fire, or ſulphureous Inflammation, hath different Names, according to the Variety of Figures and Sizes it appears under: As, 1. *Lampas*, a Lamp, when it burneth by little and little, on one Part only. 2. *Bolis*, a Dart, when the Exhalation appears kindled in a long Tract together. 3. *Trabes*, Beams, when the Inflammations appear in the ſame Place continually. 4. *Chaſma*, a Chaſm, when the Flame ſhines or glitters from the Breaks of dividing and ſplitting *Clouds*. 5. *Ignis Fatuus*, i. e. the fooliſh Fire, or Jack in a Lanthorn, when a fat unctious *Vapour* is kindled, and wafted about by the Motions of the Air, near the Surface of the Earth, like a

Light in a Lanthorn. 6. *Ignis Pyramidalis*, the pyramidical Fire, when it reſembles a Pillar of Fire ſtanding upright. 7. *Draco Volans*, a flying Dragon, when the middle Parts be thicker and broader than the Ends. 8. *Capra Saltans*, a ſkipping Goat, when it appears to have a ſkipping Motion, and to be ſometimes kindled, and ſometimes not. 9. *Stellæ cadentes*, falling Stars; when the more ſubtle Parts are burnt away, they fall by the Weight of their viſcous and earthy Matter remaining: And theſe are all the remarkable fiery *Meteors*.

CHAP. IV.

Phantaſmatography, or a *philoſophical Account of the celeſtial Apparitions*, viz. *the Rain-bow*, *Halos*, *Parheliums*, *Paraſelenes*, &c.

A. PRAY, *Sir*, why do you chuſe to uſe ſuch a long hard Word as *Phantaſmatography*, I proteſt I can hardly ſpeak it?

B. Becauſe that beſt expreſſes my preſent Deſign, which is to let you underſtand what the Opinions and Diſcoveries of the beſt Philoſophers are concerning the celeſtial *Appearances*, as the *Rain-bow*, &c. this Word being compoſed of Φάντασματα, *Fantomes*,

tomes, or *Appearances*, and Γραφὴ, a *Deſcription.*

A. But, *Sir*, by your leave, I would ask whether it be not an Innovation to call thoſe Things by the Names of *Phantoms*, *Appearances*, or *Apparitions*, which (as your ſelf ſays) are by the greateſt Philoſophers ranked with, and deemed *Meteors?*

B. Be it an Innovation, or what it will, I always chuſe to call Things by ſuch Names as expreſs what they be, not what they be not; 'tis certain thoſe Things we diſcourſe of exiſt no how but in Appearance.

A. What, I pray you, is there nothing of reality in theſe Things, as in the *Rainbow* for Inſtance, but a Form of different Colours?

B. Nothing more indeed; they all owe their Exiſtence to one common Cauſe, *viz.* the Reflection and Refraction of Light.

A. Pleaſe to explain a little more particularly the Manner how theſe *Phænomena* are produced; and firſt, how the *Rainbow* acquires his beauteous and wonderful Form?

B. The *Rain-bow* is one of the moſt ſurpriſing of all the Works of God (which the *Hebrews* call קשח אלהים, the *Bow of God*, and the *Greeks* Θαυμαντὶς, i. e. the *Daughter of Wonder*) This *Phænomenon* is ſeen in the falling *Rain*, or *Dew*, and not in the Cloud whence that *Rain*, or *Dew*, proceeds; it is cauſed by a Reflection and Refraction of the Sun's Rays from the globular Particles of *Rain*: There are often two *Bows* to be ſeen at the ſame Time, the interior, as AFB, which is more ſtrong and vivid; the exterior *Bow*, as QHD, which is more faint and weak; the interior *Bow* is formed by two Refractions of the Rays of Light, and one Reflection of them in the Drops of Water. See *Fig.* XXVII.

A. Pray, *Sir*, exemplify this Matter.

B. I will: In the interior *Bow* (*Fig.* XXVII.) let E F be two Drops of the falling Rain, and let S*a* be a Ray of Light, falling on the Drop E in *a*, from whence it is refracted firſt to *e*, thence it is reflected to E, whence it is a ſecond Time refracted to the Eye, ſuppoſe at O: In like Manner, the ſame Thing happens in the upper Part of this *Bow*, in the Drop F.

A. Well, and what are we to learn from all this?

B. Hence you eaſily underſtand the Reaſon of the Colours of the *Bow*, if you have not forgot what I delivered to you when we were diſcourſing of Light and Colours: For here you ſee the Angle COE $=40°\ 2'$ ſhall be the greateſt Angle, in which the moſt refrangible Rays can after one Reflection be refracted to the Eye; and therefore all the Drops in the Line OE, ſhall ſend the moſt refrangible Rays moſt copiouſly to the Eye, and thereby ſtrike the Senſes with the deepeſt violet Colour in that Region: In like Manner, the Angle COF $=42°\ 17'$ ſhall be the greateſt, in which the leaſt refrangible Rays can after one Reflection be refracted to the Eye; and therefore all thoſe leaſt refrangible Rays ſhall come moſt copiouſly to the Eye in the Line OF, and ſtrike the Senſes with the deepeſt Red in that Region: Do you underſtand me pray?

A. Yes, *Sir*, very well; and I alſo underſtand, that by Reaſon of the intermediate Degrees of Refrangibility of Rays coming from the Drops between E and F, the Space between E and F ſhall be painted with proper intermediate Colours; and therefore the whole Face of the *Bow* will be tinged with all the primogenial Colours in their natural Order, *viz.* Violet, Indigo, Blue, Green, Yellow, Orange, and Red, from E proceeding to F.

B. I am heartily glad to ſee you ſo very happily underſtand the Matter; you will with the greateſt Eaſe and Pleaſure underſtand the *Phænomena* of the upper, or exterior *Bow* QHD, which in ſhort are thus produced: Let G and H be two Drops in the extream Parts of the upper *Bow*; now let S*g* be a Ray falling on the Drop in G, whence it is firſt refracted to *e*, from thence it is firſt reflected to F, from F, it is a ſecond Time reflected to g, and from g it is a ſecond Time refracted to the Eye at O: Now the ſame is to be underſtood in the upper Drop H; hence the Angle $COg = 50° 42'$ is the leaſt Angle, in which the leaſt refrangible Rays can after two Reflections be refracted to the Eye; and therefore the Drops in the Line Og ſhall ſtrike the Eye with the deepeſt Red, and the Angle $COH = 54° 22'$ ſhall be the leaſt Angle, in which the moſt refrangible Rays after two Reflections can emerge out of Drops; and therefore thoſe Rays ſhall come moſt copiouſly from the Drops in the Line OH, and ſhall ſtrike the Senſe with the deepeſt Violet in that Region: And by the ſame Reaſoning, the Drops between GH ſhall ſtrike the Senſes with the intermediate Colours; and ſo the Colours in the whole Width of the upper *Bow*, ſhall lie in this Order from G to H, *viz.* Red, Orange, Yellow, Green, Blue, Indigo, Violet; contrary to the Order of thoſe in the lower *Bow*.

A. Sir, I readily perceive the Reaſon of thoſe Colours in both the *Bows*, according to the Laws of Refraction you heretofore mentioned; but, pray, why are the Colours of the exterior *Bow* ſo much fainter than thoſe of the interior one?

B. Becauſe the Light is twice reflected in the Drops of the exterior, and but once in

thoſe

thoſe of the interior *Bow*, the Light becoming fainter by every Reflection.

A. I think, *Sir*, the *Rain-bow* always appears perfectly round; doth it not?

B. Yes, accurately ſo; for the Lines OE, OF, OG, and OH, turned round their common Side, or central Line OC, ſhall with their Ends EFGH deſcribe the circular Borders, or Extremities, of the two *Bows*.

A. And do they always appear equally large?

B. Yes, all *Rain-bows* are of the ſame Dimenſions; becauſe no *Bow* can appear but under the Angles of the ſame Quantities, as before mentioned.

A. But we do not always ſee an equal Quantity of a *Bow*, I have often obſerved.

B. No, that is impoſſible you ſhould; for the Sun muſt be in the Horizon for you to ſee half the *Bow*, which is the moſt that can ever be ſeen; for then the Center of the *Bows* C is on the Superficies of the Earth; but the higher the Sun riſeth above the Horizon, the lower the Center C ſinketh beneath the Earth's Surface; and conſequently the leſs ſtill you can ſee of the *Bow*, 'till at laſt, you can ſee none at all.

A. Pray how high muſt the Sun be for the *Rain-bow* not to be ſeen at all?

B. When the Altitude of the Sun becomes equal to the Quantities of the aforeſaid Angles, under which the *Bow* appears, they cannot then be ſeen; that is, when the Sun's Height is equal to the Angle COE = 40° 2′, the inner Part E, of the interior *Bow*, deſcends the Horizon; when it is equal to the Angle COF = 42° 17′, the upper Part F, and ſo the whole interior *Bow*, will entirely vaniſh and diſappear beneath the Horizon; thus, when his Height is equal to the Angle COH = 54° 22′, the whole exterior *Bow* will be depreſſed below the Horizon, and then no Part of any *Bow* at all can be ſeen: hence all the *Winter* half Year both the *Bows* may be ſeen all the Day, the meridian Height of the Sun then at greateſt being never above 38° 30′.

A. What elſe, pray, is remarkable of the *Rain-bow*?

B. The Dimenſions in *Engliſh* Feet and Miles, I have calculated for every Part of both *Bows* (in a Tract of *Trigonometry* not yet publiſhed) at a given Diſtance, and Height of the Sun; but, becauſe 'tis not now by me, I cannot ſhew it you: However you have here learned the following Particulars: 1. That two *Bows* do appear together. 2. The Manner how they are both formed. 3. The Reaſon of the Diverſity of their Colours. 4. The

Reaſon why the Colours of each *Bow* lie in an inverſe Order to each other. 5. That the *Rain-bows* never appear but when it rains. 6. That the *Bow* is in the falling Rain, and not in the Cloud. 7. That it always appears in that Part of the Heavens oppoſite to the Sun. 8. The Reaſon why one *Bow* is ſo much more ſtrong, apparent, and vivid than the other exterior one. 9. Why they are all in themſelves of an equal Bigneſs. 10. Why we ſee at ſometimes a greater, at ſometimes a leſſer Part of them. 11. Why we can never ſee above half a *Bow* at moſt, and when we can ſee none at all. 12. That the Dimenſions of a *Rain-bow* may be computed in any known Meaſure.

A. Indeed, theſe are all exceeding curious Circumſtances, and far more than ever I underſtood before: But you have ſaid nothing of the *Rain-bows* which appear by Night in the *Moon-ſhine*; what think you of them, *Sir?*

B. They are in all Reſpects the ſame as thoſe occaſioned by the *Sun-ſhine* in the Day.

A. But, if you aſſign ſuch a natural Cauſe for the Production of the *Rain-bow*, would not there have appeared a *Bow* in all Ages and Places?

B. Yes, always ſince there have been Clouds, and Perſons to ſee the Reflection of the Sun's Light from the Particles of falling Rain.

A. Why, there have been Clouds ever ſince the Creation, have there not?

B. Yes, undoubtedly, and Rain too.

A. Pray, then, how could the *Rain-bow* be any Thing of a miraculous Production, or be made the Sign of a new Covenant, which God made with *Noah* and the *New World*, as related, *Gen.* ix?

B. Indeed, *Sir*, I cannot reſolve you; you muſt enquire this of thoſe divine Philoſophers, who can eſtabliſh any Point of Divinity, though ever ſo repugnant to the Principles of natural Philoſophy, and the Mathematicks; or of thoſe, who, in a twelve-month's Time, can make you new Heavens, and a new Earth, and deſtroy them again when they have done.

A. Why then, I think, 'tis Time to divert our Diſcourſe of the *Rain-bow* to ſome other Subject: Pray, therefore, what do you ſay of thoſe *Phænomena* we call *Halos*?

B. They are Circles ſomewhat a-kin to the *Rain-bow*, which appear about the Sun and Moon, and ſometimes variouſly coloured.

A. Pray what are the moſt remarkable Particulars in the *Halo*?

B. The

B. The following; 1. They have always the Sun or Moon for their Center. 2. They never appear in a rainy Sky, but in a rimy and froſty one. 3. They appear Blue on the exterior Limb, or Border, and Red on the interior. 4. The Air contained within them is more obſcure than the ambient Air without round about them. 5. The Limb of a *Halo*, or Wedth of its Circle, is about half a Degree, or 30 Minutes. 6. The Diameter of the whole Circle of the *Halo*, is about 44 or 46 Degrees, more or leſs. See *Fig.* XXVIII.

A. And, pray, is the *Halo* formed in the ſame Manner as the *Rain-bow?*

B. The *Halo* is formed by the Refraction of the Rays of Light, without any Reflection, as in the *Rain-bow*; and this Refraction of the Light in the Hail-ſtones in the Air, will be ſtrongeſt at about 22°, or 22° 30′, diſtant each Way from the Sun or Moon, and gradually decay both Ways as the Diſtance increaſes or decreaſes; and conſequently, at that Diſtance there will be formed a Circle, we call the *Halo*, about the Sun or Moon, which *Halo*, as often as the Hail-ſtones are duly figured, may be coloured; and then it muſt be red within by the leaſt refrangible Rays, and blue without by the moſt refrangible ones: And this is the Subſtance of all we know worth mentioning of the *Halos*.

A. Then a Word next, if you pleaſe, concerning the *Parhelias*; pray what are they in a philoſophical Senſe, and why ſo called?

B. The *Parhelia*, are what the Vulgar call Mock-Suns, and *Paraſelenes*, are Mock-Moons, which ſometimes appear in the Heavens, and are only Repreſentations of the Face of the true Sun or Moon by way of Reflection in the Clouds; they are ſo called, becauſe they appear παρα τον ἥλιον, beſides the true Sun, and παρα την σελήνην, beſides the true or real Moon.

A. In what Manner do they appear?

B. Thus: 1. There is obſerved a very great white Circle parallel to the Horizon, as ACDB paſſing through the true Sun at S. See *Fig.* XXIX. 2. In the parts of this white Circle appear the *Parhelia:* As in 1629, *March* 29, there appeared at *Rome* 4 Mock-Suns, as ABCD, to a Spectator in the Obſervatory at O; though not all of them equal, nor equally ſtrong and vivid, nor of equal Duration. 3. They are in Number unequal, being ſometimes four, as here, ſometimes more or leſs. 4. They appear ſometimes tinged with the Colours of the *Rain-bow*, now ſtronger, now fainter. 5. *Halos* frequently appear at the ſame Time; as in the Caſe now mentioned, there appeared two broken ones, as the interior one FGH, very ſtrong and *Rain-bow* like, and the exterior one IABK, paſſing through the two *Parhelia* neareſt the Sun AB, but ſo weak and faint as ſcarcely to be ſeen. 6. Among theſe four *Parhelia*, one, *viz.* the *Parhelium* B appeared to have a Tail, Comet-like, extending to E, the Part oppoſite to the Sun S.

A. But, *Sir*, in viewing this Scheme, doth not I repreſent the Point vertically over the Obſervatory O, as well as the Center of the great white Circle; and ſo the Spectator would ſee the true Sun, the *Halos*, and the two *Parhelia* AB before him, and the other two CD behind him; would he not?

B. Yes, that is the right Way to conceive a true Notion of the *Phænomenon.*

A. Pleaſe to let me know how the Philoſophers ſay they are formed.

B. The great white Circle all around you is formed by the Reflection of the Sun, from thoſe icy Particles floating in the Air of the ſame Height of the Sun; and therefore the Sun muſt be in it, as at S: The *Halos* FH and IK are produced as before ſaid: The *Parhelia* ABCD are produced by two Refractions, and one Reflection of the Sun's Rays falling on the icy Particles in certain Parts of the white Circle; whence there is an Image of the Sun not only formed, but painted with the Colours of the *Bow*: But the Cauſes of theſe *Phænomena*

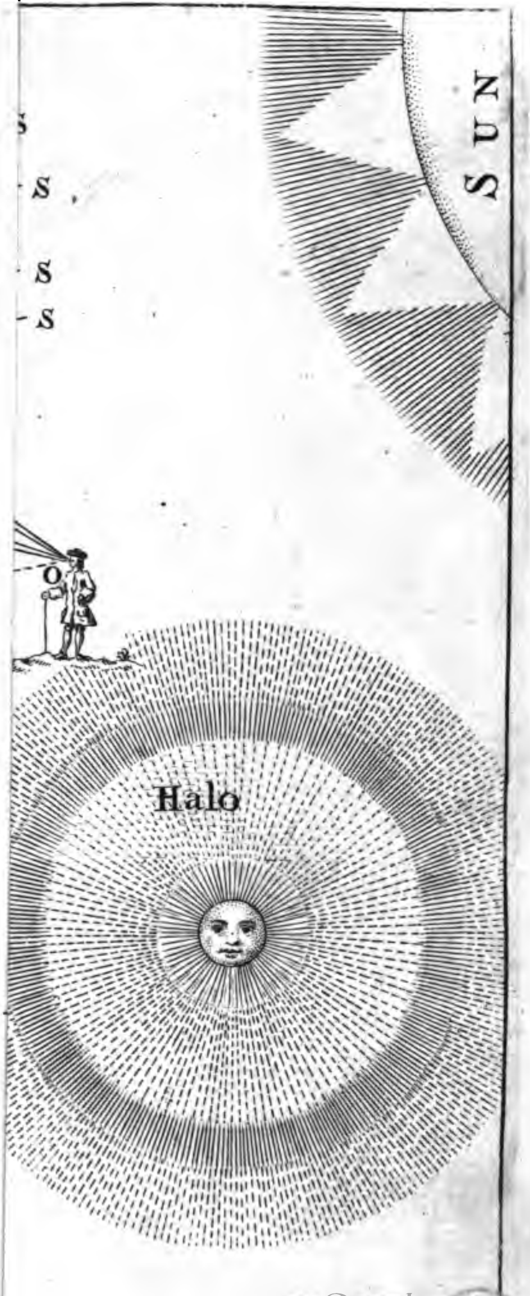


Plate VIII. Page 18

mena are not ſo obvious as thoſe of the *Rain-bow* and *Halos*, and therefore we leave them.

A. But, before we quite diſmiſs this phantaſtic Subject, pray give an Hint what that *Phænomenon* may be we call *Virgæ*?

B. This is only an Apparition of the Sun's Rays darting through the Interſtices of the Clouds, or otherwiſe, in the Form of a Bundle of Rods as it were. And now, from thoſe Things which are ſituated ſo remote from us, and in a Region altogether inacceſſible to Mankind, let us deſcend to the Contemplation of the manifold Curioſities and Wonders diſcovered in a Place we know better, and nearer Home; to wit, in the Globe of our Earth.

A. With all my Heart, *Sir*; for I cannot ſay, indeed, but that I am almoſt weary with travelling ſo long through all the ætherial Regions of the Univerſe; yet, as it hath been on the Wings of Contemplation, and ſaturated with all the delightful Curioſities Nature could afford, I am ſo far from regreting it, that I count it the beſt and moſt profitably ſpent Part of my Time.

THE *Philoſophical Grammar:* Or, VIEW of Modern Philoſophy.

PART IV.

GEOLOGY:

CONTAINING,

I. A philoſophical View of the *terraqueous Globe.*
II The Philoſophy of *Earths*, *Stones*, *Metals*, *Minerals*, &c.
III. The Philoſophy of *Water*, viz. the *Seas*, *Rivers*, *Springs*, &c.
IV. The Philoſophy of *Plants* and *Vegetation.*
V. The Philoſophy of *animal Bodies*, viz. the *humane Body*, *Brutes*, *Fowls*, *Fiſhes*, *Inſects*, *Reptiles*, *Shell-Animals*, &c.

Shewing the wonderful Diſcoveries of the modern Naturaliſts in thoſe Parts of the Science.

CHAP. I.

Geology, or the general Doctrine of the Globe, of its various Diviſions and Subdiviſions, of the Viciſſitude of Seaſons, and other general Affections.

A. PRAY what is imported by the Word *Geology?*

B. A Diſcourſe of the Earth in general, or terraqueous Globe, as conſiſting of Land and Water; from the *Greek* Words Γῆ, the *Earth*, and Λογος, a *Diſcourſe*.

A. How is the Earth divided?

B. The firſt great and moſt general Diviſion of the Earth is into Land and Water; which again are ſeverally ſubdivided into other leſſer Parts.

A. Pray how is the Land ſubdivided?

B. Into the following Parts, *viz.*

1. *Continents*, which are great Tracts of main Land, containing whole Countries and Kingdoms, as *Europe*, *Aſia*, *Africa*, and *America*.

2. *Iſlands*, or Parts of Land environed by the Sea, as *Britain*, *Japan*, *Madagaſcar*, &c.

3. *Peninſulas*, which are Parts of Land encompaſſed by Water, excepting on one Part by which it is joined to the main Land, or Continent, as *Morea*, &c.

4. *Iſthmus*, is that Neck of Land joining the *Peninſula* to the main Land.

5. *Promontories*, or *Capes*, are thoſe high Parts of Land which run far out into the Sea in a Point, as the *Cape of Good Hope*, &c.

A. And, pray, what are the Subdiviſions of the Water on the Globe?

B. Theſe following, *viz.*

1. *Oceans*, are thoſe vaſt Collections of Water which cover ſome greater Parts of the Earth's Surface, as the *Atlantick Ocean*, *Mare del Zur*, &c.

2. *Seas*; thoſe are leſſer Aſſemblages of Water, which lieth before, and waſheth the

Coaſts of ſome particular Countries, as the *Ethiopick*, *Indian*, *Arabian*, &c. Seas.

3. *Gulphs*, are thoſe Parts of the Sea every where environed with Land, except one Paſſage whereby it communicates with the Sea, as the *Arabian Gulph*, &c.

4. *Straits*, are thoſe narrow Paſſages of Water which either join a *Gulph* to the neighbouring Sea, or one Part of the Sea or Ocean to another, as the *Straits of Gibraltar*, &c.

5. *Rivers*, are Streams of freſh Water ariſing from ſome Fountain Head, which by a continued Current arrive and diſembogue themſelves into the Sea.

A. What other Diviſions do you make on the Surface of the Globe?

B. The Earth is again divided, with Reſpect to the Length of Days and Nights, into Climates.

A. Pray what do you call a *Climate*?

B. *Climates* are ſuch Parts of the Earth's Surface on each Side the Equator, and parallel thereto, that the artificial Day in one ſurpaſſeth that in the other by half an Hour.

A. Are there yet any farther Kinds of Diviſions of the Earth's Surface?

B. Yes, and a very remarkable one too, *viz.* into the *Zones*, called the torrid, temperate, and frigid *Zones*.

A. Pray what doth the Word *Zone* mean?

B. It is derived of the *Greek* Ζώνη, a *Belt*, or *Girdle*; becauſe they, being large parallel Parts of the Earth's Surface, do encompaſs the Globe of the Earth, as a *Belt* doth the Body of a Man.

A. What is the torrid *Zone*, and why is it ſo called?

B. In the Map adjoined, you may obſerve a certain Space on the Earth's Surface, over the middle of which paſſeth the Equator, and is included between two double Parallels, one towards the *North*, called the Tropick of *Cancer*, and the other *Southward*, called the Tropick of *Capricorn*; over all this Space, from the *North* to the *South*, you may obſerve the *Zodiac*, or the Sun's Path, doth paſs; and conſequently doth at ſome Time of the Year or other paſs twice over every Part thereof, and by its perpendicular Rays doth greatly heat and ſcorch it; and from its being thus torrified by the Sun's exceſſive Heat, it is called the torrid *Zone*.

A. Pray which do you call the temperate *Zones*?

B. Theſe are two Tracts lying next the torrid *Zone*, one on the *North*, the other on the *South*, each bounded by, or contained within the Tropicks and polar Circles, as are plainly diſcerned in the Map;

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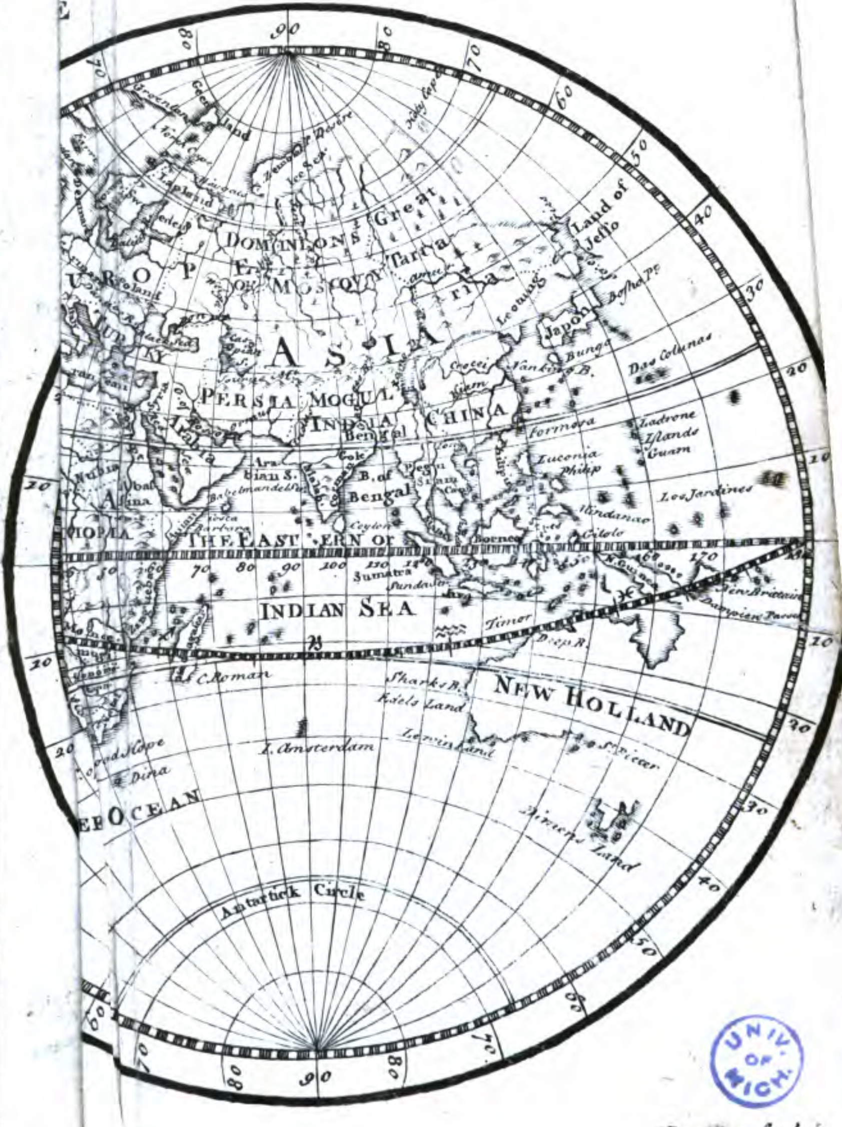


Bowen Sculp.

Plate

UNIV. OF MICH.

they are called temperate becauſe the Sun never paſſeth over any Part of them, but ſhining oblique on them, maketh them to have always a moderate Degree of Heat and Cold.

A. And where do you place the frigid *Zones?*

B. They are thoſe two Tracts of the Earth's Surface contained within the polar Circles, *Northward* and *Southward*, as you ſee in the Map; over the Center of each of theſe is the Pole; the Sun being at a great Diſtance from theſe, and abſent ſo long from ſeveral Parts thereof, together with the great Obliquity of his Rays when preſent, cauſeth prodigious Cold continually over all thoſe Parts; and they are therefore called the frigid *Zones.*

A. Pleaſe to let me underſtand the Reaſon of the different Degrees of Heat and Cold, in any one Place through the Year.

B. This will be better apprehended if we firſt diſcourſe a little of the various Seaſons, and their Cauſes, in which the Differences of Heat and Cold are found; and firſt, if you pleaſe, we will enquire the Reaſon of the different Length of Days and Nights.

A. That will be very acceptable to me; for I muſt confeſs to my Shame, though I have lived ſo many thouſand Days and Nights, I could never yet tell why one was longer or ſhorter than another; be pleaſed therefore to make the Matter evident, if poſſible, by a Scheme.

B. Yes, I will warrant it is poſſible; caſt your Eyes therefore on *Fig.* XXXI, and view well the Situation of the Globe; it is there in its proper Poſition for *London*, which you ſee in the *Zenith* at I, whoſe Horizon is the Line HO, all under which to us is dark, and all above it light.

A. Very good, ſo far I can follow you; pray go on.

B. Then next you muſt conceive the great Circle OPQ to be the Meridian of *London*, on which the Sun comes every Day at Noon, and every Night at Midnight, on ſome Part of it or other.

A. But, pray, why do you ſay on ſome Part or other?

B. Becauſe the Sun is never preciſely on the Meridian in the ſame Place two Days together; but every Day declines from, or approaches nearer to, the equinoctial Line ÆQ, which ſurrounds the Earth in the Middle.

A. Pray how far does the Sun decline from the Equinoctial at moſt?

B. The Sun from *March* 11, to *June* 11, declines from Æ to T, which is 23° 30′, or 1633¼ *Engliſh* Miles on the Earth's Surface; then from *June* 11, to *Sept.* 12, it returns again from T to the Equinoctial Æ, from which it paſſeth to V, where it is found about *December* 10; and thence returns again to Æ by *March* 10.

A. Then I ſee the Sun is neareſt *London* at T, at a mean Diſtance in Æ, and fartheſt of all from us at V.

B. Yes, it is ſo; now obſerve the Sun in the Meridian at theſe three ſeveral Places T, Æ, V; then, becauſe the Earth turns each Day once round its Axis PD, the Sun in each of thoſe Places will deſcribe a Circle; one of which, *viz.* the middle one, ÆQ, will be the Equinoctial it ſelf; and the other two, TR, and VW, will be parallel thereto on either Side, and are the Tropicks of *Cancer* and *Capricorn:* Do you underſtand me, *Sir?*

A. Yes, pretty well; you mean that the three Lines TR, Æ, VW, repreſent the Path of the Sun from Noon in T, Æ, V, to Midnight in R, Q, W, on *June* 10, *March* 10, and *December* 10; do you not?

B. Yes, you take me very right; now it is obvious, when the Sun has paſſed half Way from Noon to Midnight, it will be found in the Line PD (the ſame here as the Earth's Axis) in the Points G, Y, M, and that then it is 6 a-Clock; alſo, when it touches the Horizon in X, Y, Z, it there ſetteth from our Sight, and conſequently

termi-

terminateth the Day, and beginneth the Night, on theſe Days.

A. Very well, *Sir*, I believe I ſee your Concluſions already.

B. Indeed, *Sir*, they are very evident: For, 1. Suppoſe the Sun in Æ the Equinoctial, then it is apparent, that it will on theſe Days, *viz. March* 10, and *Sept.* 12, be in the Horizon Y preciſely at 6 a-Clock; and therefore his Path by Day ÆY, will be juſt equal to the ſame by Night YQ. 2. Suppoſe the Sun at T, as on *June* 10, then it is at 6 a-Clock in G above the Horizon a great Way; but it deſcends the Horizon at X; and therefore the daily Arch TX is longer than the Arch by Night XR, by the Difference GX. 3. Suppoſe the Sun in V, then the diurnal Arch VZ is juſt as long as the nocturnal Arch XR before, and the nocturnal Arch ZW is here the ſame Length with the diurnal Arch TX, in the foregoing Caſe: Do you underſtand me hitherto?

A. Yes, I believe I do: As the Sun declineth from Æ to T, and back again, the Length of Days exceeds the Length of Nights, in as much as it muſt paſs ſome Diſtance beyond the 6 a-Clock Line GY, before it can come to the Horizon; and on the contrary, while it is between Æ and V, it meets with the Horizon before it comes on the 6 a-Clock Line YM, and therefore the Days are ſhorter than the Nights, by juſt ſo much as the Nights are ſhorter than the Days in the other Caſe; this is what you mean, is it not?

B. Yes, the very ſame: I have only this to obſerve, that the farther you go *Northward*, the greater is the Difference or Inequality of Days and Nights, and the contrary.

A. That I alſo perceive plainly from the Figure; for the nearer HO inclines to ÆQ, the greater will be TX, and the leſſer VZ, or the greater will be GX, or MZ, the Difference of Day and Night: But, pray, what means that obſcure Part of the Night, comprehended between HOAB, which is neither dark nor light?

B. It is the *Crepuſculum*, or what we call the *Twilight*, the Line AB being 18 Degrees below the Horizon HO, and during the Time the Sun paſſeth from HO, to AB, in the Parallel of any Day, his Rays are partly refracted by the *Atmoſphere*; and ſo we have ſome faint Light 'till he gets below the Limit AB, and we are left in total Darkneſs, as I told you from *Fig*. XXVI.

A. I underſtand you mean, it is *Twilight* while the Sun paſſeth from X to R, from Y to S, and from Z to M, on the Days the Sun deſcribes the Parallels TR, ÆQ, and VW; do you not?

B. Yes,

B. Yes, I do; and hence, at *London* you may obſerve, that when the Sun is in T, that is, in the Tropick of *Cancer*, there is no dark Night at all; for the Parallel of that Day TR doth not touch AB, nor will it for about a Month before and after; that is, from *May* 11, to *July* 10, there is no dark Night.

A. Pray when doth the ſhorteſt *Twilight* happen in all the Year?

B. On *October* 1, and *Febr*. 19; for then the Sun deſcribes the Parallel, whoſe Diſtance *eo* is the leaſt, between HO and AB, of any other whatſoever.

A. Well, *Sir*, I can but thank you for your Labours to rectify my Notions of *Day*, *Night*, *Twilight*, &c. which, though they are common Things, yet, I never had a good Notion of them before now: Nor do I yet well conceive the Reaſon and Manner of the various Changes and Viciſſitudes of the Seaſons which happen through the Year; and, if you could repreſent this to me in a Figure, I ſhould be greatly obliged to you.

B. I have contrived a Scheme for that very Purpoſe (*Fig*. XXX.) which pleaſe only to view very carefully, and you will ſee therein a natural Repreſentation of a whole Year.

A. *Sir*, I obſerve it with all Diligence, and ſee ſeveral Things therein very remarkable;

able: But, yet, I beg you would pleaſe to point them out in the natural Order, in which they ſhould be conſidered, that I may the better apprehend the Deſign of the whole.

B. That I will; and *firſt*, you obſerve in the Center of the Scheme is placed the Sun S, about which, at a great Diſtance, is the circular Orbit of the Earth, called the *Zodiack*, divided into its 12 Signs, *viz.* ♈, ♉, ♊, ♋, ♌, ♍, ♎, *&c.* in which you ſee the Earth in 4 ſeveral Poſitions; the *firſt* in *Aries* ♈; the *ſecond* in *Cancer* ♋; the *third* in *Libra* ♎; the *fourth* in *Capricorn* ♑; within this there is a dotted Circle of Months, ſhewing the Time of Year when the Earth is in any Part of her Orbit: Now with regard to the Earth it ſelf, you ſee its Poſition every where is ſomewhat inclined to the Plane of her Orbit; that is, the Earth's Axis NS doth not ſtand perpendicular to the Plane of her Motion, or (which is the ſame) is not parallel to the Axis of the ſaid Plane, but maketh an Angle therewith equal to the Angle made by the Interſection of NS with AK; for this AK you ſee is always a Diameter of that Circle which boundeth Light and Darkneſs on the Earth's Surface, and is every where perpendicular to the Plane of the Earth's Motion, or parallel to the Axis of that Plane. Now the Earth's Axis, thus inclined, is every where parallel to it ſelf; that is, the Angles N♈A in the *firſt*, N♋A in the *ſecond*, N♎A in the *third*, and N♑A in the *fourth* Poſition of the Earth, are all equal to each other, and ſo are equal in every other Poſition through its Orb. The Quantity of this Inclination or Obliquity of the Earth's Poſition is 66 Degrees 30 Minutes, equal to the Angle N♈R, &c. Now it is evident, that by Means of this parallel Inclination of the Earth, the *North* and *South* Parts of the Earth, or its Poles N and S, will be ſometimes nearer the Sun, ſometimes farther of, and ſometimes each Pole will be equally diſtant from the Sun; and from hence we ſhall ſee the Reaſon of, and how the Seaſons are all produced. For, 1. In the *firſt* Poſition of the Earth in *Aris* ♈, about the 12th of *Sept.* and in the *third* Poſition in *Libra*, in *March* the 10th, it is evident the Sun doth there enlighten the Earth from Pole to Pole, or the Circle bounding Light and Shadow doth then paſs through the Poles, and conſequently at equal Diſtances from the Equator ÆQ (in which the Sun then appears) the Sun's Heat will be equal on both Sides; and thus an Equality of Days and Nights, joined with a mean Proportion of Heat, conſtitute thoſe two Seaſons of the Year, we call *Spring* and *Autumn*. 2. Again, in the *fourth* Poſition of the Earth in ♑, about the 10th of *June*, when the Sun will appear in the oppoſite Sign *Cancer* ♋, it is plain the *North* Pole N, and all the Parts about it to the Diſtance of A, will be ſituated nearer towards the Sun than before; and all the *South* Parts removed farther from the perpendicular Rays thereof. The perpendicular Rays of the Sun here fall on R, which is diſtant from the Equator Q, *Northward* 23° 30′; and therefore all Places in *North* Latitude, receiving the Sun's Rays nearer their *Vertex*, or *Zenith*, will find a greater Degree of Heat, and a longer Continuance of his Light by Day, and therefore have now their *Summer*, as at *London*, while all the Inhabitants of *Southern* Latitude have their *Winter*. 3. *Laſtly*, in the *ſecond* Poſition of the Earth in *Cancer* ♋, the Sun will ſeem in *Capricorn* ♑: It is manifeſt the *North* Parts will here be in Darkneſs, and have their *Winter*, as they in *South* Latitude had theirs, in the laſt Poſition; that is, by being removed farther from the Perpendicularity of the Sun's Rays; and under the Obliquity of the Sun's Rays the Heat is diminiſhed, and alſo the Duration of his Light by Day; which together muſt cauſe *Winter* in all the *Northern* Latitudes. I hope you have underſtood me through this long Harangue.

A. Indifferently I have; and can eaſily ſee from this Scheme the Reaſon why we muſt have thoſe Viciſſitudes of Seaſons, as you have explained it: But I really thought *Summer* had been occaſioned by the Sun's being very near us, and the *Winter* by his going farther from us, 'till I ſee you aſſign other Reaſons for it.

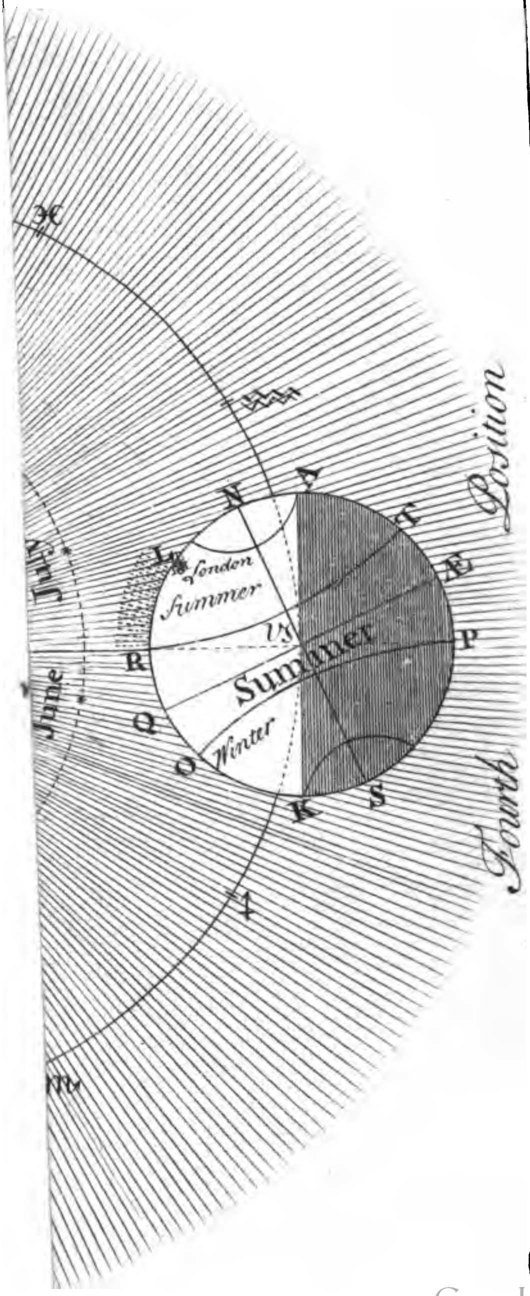
B. Aye, that is the general Miſtake of common People, they think the Sun is really nearer in *Summer*, and farther off in *Winter*; when the Truth is juſt the contrary, for the Sun is much nearer in the *Winter* to our Earth than it is in the *Summer.*

A. This is a ſtrange Paradox, indeed; pray how do you make it out to be ſo?

B. Nothing is more eaſily proved; for look once more on the Scheme, and heed it well, and you will ſee the Earth's Orb is not a Circle, but an Oval, whoſe longer Diameter is ♋ S ♑, in which the Sun is; but much nearer ♋, in which the Earth is at *Winter*, than ♑, its Place in *Summer.*

A. I underſtand you very well, *Sir*, you mean the Diſtance SP, is leſs than the Diſtance SR; which I did not before obſerve indeed, though I might, for it is obvious enough.

B. It is right, I ſee you apprehend me well; and therefore you will alſo underſtand that the *Summer* half Year, is ſomewhat longer than the *Winter* half Year; that is, the Part of the Earth's Orb ♎ ♑ ♈, is



Bowen Sculp.

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is greater than the other Part ♎ ♑ ♈, and therefore more Time will be requiſite to paſs the *Summer* half Year than the *Winter*, by about 8 Days; and hence alſo, the Sun will ſeem to move ſomewhat ſlower in the *Summer* than in *Winter*.

A. All theſe Things evidently follow indeed, *Sir*, from the Conſideration of the Earth's Orbit being an Ellipſis: But I am not fully ſatisfied about the Sun's Heat being ſo weak and faint in the *Winter*, when the Sun is really neareſt to us; and ſo very ſtrong and intenſe when the Sun is really farther by much from us.

B. You will ſoon ſee the Reaſon of that when you conſider: 1. That it is not the Rays which fall on us, but thoſe which are reflected back from the Earth's Surface, that chiefly heat us. 2. That thoſe which fall on us moſt directly, or neareſt to the Perpendicular, are the moſt in Quantity, and act on us with the greateſt Force: Thus, in *Fig.* XXXII. the Rays of the Sun, on the longeſt Day of *Summer*, fall on *London*, under the Angle TLO, in *Spring*, or *Autumn*, under the Angle ÆLO, and in the midſt of *Winter*, under the Angle VLO, and the Quantity of thoſe Angles are reſpectively 65°, 38° 30′, 15°; wherefore the Force of the Sun's Rays in each of thoſe Caſes, ſhall be proportioned to the Sines of thoſe Angles, which are, as 88294,

62251,

62251, and 25881; that is, 10, $7\frac{5}{10}$, 3, nearly, for thoſe Numbers are in proportion to the Sines TA, ÆB, and VC, of the aforeſaid Angles: The Quantity of the Rays alſo falling on the ſame Extent of Surface is greater or ſmaller, as their Obliquity is leſſer or greater, and ſo the Intenſity of Heat is greater and ſmaller; and therefore the Sun's Heat in *Winter* muſt be weakeſt, becauſe then the Sun's Rays fall moſt obliquely on us. Beſides, 3. That Rays of the Sun paſs through a much greater Part of the *Atmoſphere* in the *Winter* than in *Summer* (as is evident from viewing the ſame in the ſecond and fourth Poſition of the Earth in the Scheme) and therefore muſt be, when arrived to us at L, more weak and faint in the firſt than in the latter Caſe.

A. Sir, you need ſay no more; I am ſufficiently convinced there is abundant Reaſon for the Differences of Light and Heat, and all the Variety of Seaſons through the Year, though I never was ſo happy as to underſtand it before: We will now proceed to diſcourſe of the internal Subſtance of the Globe, if you pleaſe; for I have ſeveral Matters of great Importance to enquire of you about, relating to its Conſtitution, Texture, and various conſtituent Parts.

B. Sir, none will more gladly take the Pleaſure to reſolve you, according to the Judgments of the beſt Philoſophers of the Age, than your humble Servant: Pray therefore make a beginning.

CHAP. II.

Geography, or the Philoſophy of the Conſtitution, Texture, and conſtituent Parts of the Earth, deſcribing the various Stratas of Earths, Foſſils, Minerals, Metals, Stones, and other ſubterraneous Subſtances.

A. PRAY what is the internal Make and Conſtitution of the Globe of our *Earth*?

B. The *Earth* generally ſpeaking is conſtituted of the two Subſtances of *Earth* and *Water*; the *Water*, as the lighter Part, poſſeſſing the greateſt Part of its Superficies; and the *Earth*, being the heavier Body, making up the internal Compoſition; about which it is, I preſume, you here ſolely enquire.

A. Yes, what I would know is, of what the internal ſolid Body of the *Earth* doth conſiſt?

B. To this I can only anſwer, that ſo far as it is within our Scrutiny near the Superficies, we find it to conſiſt of different *Strata*, or *Layers* of *Earth*, *Minerals*, *Metals*, *Oars*, *Stones*, and various other compound Bodies both hard and ſoft: But what the more internal Parts, or Compoſition of it may be, we can tell but very little concerning: However the deeper you go, the ſolider and more compact you find its Matter to be, and the more firmly and ſtrongly does it cohere together; yet it is very certain that within the Entrails of the *Earth*, are many Hiatus's, Receſſes, Windings, Conveyances, and vaſt Receptacles of Water, ſulphureous Subſtances, *&c.* which are often the Cauſe of Earthquakes, and ſupply *Volcanoes* with their fiery Eruptions, as *Mount Ætna*, &c.

A. What do you ſuppoſe to be in the very Middle of the *Earth*; that is, in and about its Center?

B. No Body can certainly tell; the *Earth*'s Center is near 4000 Miles from us, and we can penetrate towards it but a few Fathoms; how very unlikely then is it, we ſhould know any Thing at ſuch a vaſt and impervious Diſtance? However the learned Dr. *Halley* has made it very probable, that

a

a great magnetic Body, or Load-ſtone, doth poſſeſs the central Parts of the *Earth*; which occaſioneth the Variations and Declinations of our magnetic Needles, which always conform themſelves to the Site and Direction of this central Magnet, or Load-ſtone; which is ſuppoſed to deviate from the *North* and *South* Points, and from the horizontal Poſition, with Reſpect to us.

A. If that be ſo, it is very wonderful, and a noble Diſcovery: But, pray, what is it binds the ſeveral Parts of the *Earth*, or makes them cohere ſo cloſely together?

B. The Coherence of the *Earth* is entirely owing to the Power of Gravity, or the Weight of its conſtituent Parts; whence, as I before ſaid, it is reaſonable to believe the moſt weighty and ſolid Bodies lie neareſt the Center of the *Earth*, as being the Center of Gravity it ſelf.

A. Well then, ſince the more interior Parts of the *Earth* are ſo little known, we leave them, and content our ſelves with what is to be known near the Superficies of it on which we live; and, pray, what do you firſt obſerve thereof?

B. That it does conſiſt of different heterogeneous Bodies intermixed with one another, of different ſpecific Gravities, diſpoſed in Manner of Beds, which are called *Strata*, or *Layers* of *Earth*, *Stones*, *Minerals*, &c. one under another.

A. Pray in what Order do theſe *Strata*, or Beds of *Earth*, &c. lie among themſelves?

B. That they do not lie in Order of their ſpecifick Gravities, is evident (and ſo not every where alike) from the Order of thoſe obſerved in digging a Well at *Amſterdam* 232 Feet deep; which was thus, 7 Feet of Garden Mould; 9 of Turf, or Peat; 9 of ſoft Clay; 8 of Sand; 4 of Earth; 10 of Clay; 4 of Earth; 10 of paving Sand; 2 of Clay; 4 of white Loam; 5 of dry Earth; 1 of muddy Earth; 14 of Sand; 3 of a ſandy Clay; 5 of Sand, mixed with Clay; 4 of Sea Sand, mixed with Shells; then 102 of Clay together; and *laſtly*, 31 of Loam: Thus you ſee the different Make of the outward Parts of the *Earth*, which is very different in different Places.

A. Pray how came the Diſpoſition of thoſe various *Strata*, or Beds of *Earth* and *Minerals*?

B. This is not known as to the Time; ſome ſay at the Creation, others at the Flood; others ſuppoſed in the *chaotick* State of the *Earth* the heavier Bodies ſubſided, and lay in this Order by the Laws of Gravitation; but Experience rather contradicts than confirms this *Hypotheſis*.

A. What Diſtinction, or Diviſion, do you make of earthy Subſtances or Bodies?

B. They may be reduced to theſe general Heads: 1. Earths. 2. Ores. 3. Foſſils. 4. Minerals. 5. Metals. 6. Stones. 7. Extraneous Bodies or Subſtances.

A. What do you include under the firſt general Head of *Earths?*

B. All thoſe ſofter earthy Subſtances we call Clay, Loam, Marl, Sand, and different Species of *Earths*, as *Terra-Japonica, Lemnia, Armenia*, &c.

A. Pray what do you think to be the Cauſe of thoſe Differences of earthy Subſtances now mentioned?

B. The Reaſon why they are differently hard, ſoft, coloured, qualified, *&c.* ariſeth from different Degrees of the univerſal and ſpecifick Properties of the original conſtituent Particles of Matter, which each different Species poſſeſſeth in a different Meaſure; and this is the moſt that can be known of this Matter.

A. Pray what do you include under the ſecond Head of *Ores?*

B. Thoſe *Earths* which contain conſiderable Quantities of metalick Particles; being that which is dug out of Mines, and whence Metals are extracted, and is denominated accordingly, as *Gold-Ore, Silver-Ore*, &c.

A. How came the *Earth* to be enriched with the Seeds of thoſe metalick Subſtances?

B. No doubt by the all-wiſe Creator, for the manifold Uſes of Mankind.

A. Pray what terreſtrial Bodies do you intend by *Foſſils*?

B. Though *Foſſils* be a general Name for every Thing which is dug out of the *Earth*; yet I here intend thereby, 1. *Salts*, 2. *Sulphurs*, and ſuch like Bodies, which cannot be ſo well reduced to the Heads of *Minerals*, *Metals*, and *Stones*.

A. Pray what is the Nature of *Salt*, and the Kinds of it?

B. *Salt* (ſaith Monſ. *Lemery*) is a fixed incombuſtible Subſtance, that gives Bodies their Conſiſtence, and preſerves them from Corruption, and renders Bodies ſapid more or leſs as it is diverſely mixed in them; there are various Kinds of *Salts*, as fixed, volatile, eſſential, and foſſil; and ſaline Subſtances, as *Alum*, *Borax*, *Nitre*, *Tartar*, *Vitriol*, *Sal-Ammoniack*.

A. Pray give me ſome ſhort Account of the Nature of theſe ſeveral Kinds of *Salt*.

B. I will, but it muſt be very brief for want of Time.

1. *Foſſil Salt*, is that which is called *Salt Gemm*, by Reaſon of its Tranſparency, and is altogether like the *Salt* we uſe with Food; it is dug out of the Mountains in many Places, as *Poland*, *Catalonia*, *Perſia*, and in the *Indies*.

2. *Fixed Salt*, is that which remains after Calcination, and doth not riſe, or is not rarified by Heat.

3. *Volatile Salt*, is that which eaſily riſeth, and flieth off in inſenſible Steam and Vapour; ſuch are the *Salts* of Animals.

4. *Eſſential Salt*, is that which is obtained from Plants by Chryſtallization; and is a natural *Salt* between *fixed* and *volatile*.

5. *Alum*, or *Roch Alom*, is a very binding *Salt*, found in the Veins of the Earth in many Places of *Europe*; being taken thereout in large tranſparent Pieces.

6. *Borax*, a green coloured mineral *Salt*, found in the Veins of *Braſs*, *Silver*, or *Gold Ore*.

7. *Nitre*, or *Salt Petre*, is a *Salt* impregnated with abundance of Spirits out of the Air, which renders it *volatile*; it is found among the Stones and Earths of old Buildings; and is ſometimes generated from Urine falling on Stones, &c. It is the Spirit of this Salt that kindles the Sulphur into a Flame in *Gunpowder*, *Lightening*, &c.

8. *Tartar*, is a terreſtrious *Matter*, or earthy *Salt*, which ſticketh to the Side of Veſſels, being ſeparated from the Liquor by Means of its Fermentation; as that in *Wine Casks*, &c.

9. *Vitriol*, is a *Foſſil*, compounded of an *acid Salt*, and *ſulphureous Earth*; there are 4 Sorts of it: 1. *Blue*, found in the Mines

of Copper in *Hungary*, and *Iſle of Cyprus.* 2. *Green*, found in *Germany*, *Italy*, and *England.* 3. *White*, and 4. *Red Vitriol*; this laſt was brought to us lately out of *Germany*, and is called *natural Colcothar*, or *Chalcitis.*

10. *Sal-Ammoniack*, is either natural or artificial; the Natural is found in many Parts of *Africa*, and very hot Places under the torrid *Zone*; the Artificial is made at *Venice*, and diverſe other Places.

A Pleaſe, in the next Place, to tell me what *Sulphur* is, and the Bodies you call *ſulphureous*?

B. Sulphur, is an inflammable *Foſſil*, found in many Places in *Europe*, eſpecially in *Sicily*; is of two Sorts: 1. The *Greyiſh*, called *Quick Sulphur*; it is a Sort of Clay, apt to crumble, ſoft, and ready to take Fire; it conſiſts of an *Oil*, an *acid Salt*, and *Earth.* 2. *Yellow*, or common *Sulphur*, called *Brimſtone*; this containeth much *Oil*, an *acid vitriolick Salt*, and but little *Earth.*

A. Pray, *Sir*, what do the *Chymiſts* mean by that Principle they call *Sulphur*; not *Brimſtone* ſure, do they?

B. No, no; they mean an *Oil*, which is called *Sulphur*, by Reaſon of its Inflammability, and is a ſweet, ſubtile, unctious Subſtance; which is ſaid to cauſe the Diverſity

ſity of Colours and Smells, and to give Beauty or Deformity to Plants, *&c.* according to its Diſpoſition in Bodies.

A. What Bodies do you reckon amongſt the ſulphureous Kind?

B. Theſe following: *Arſenick*, *Bitumen*, and its various Kinds, as *Ambergreaſe*, *Aſphaltos*, *Naptha*, *Amber*, alſo *Petroleum* is reckoned of this Claſs.

A. Pray rehearſe me alſo a ſhort Account of the Nature of theſe Bodies alſo.

B. I deſign it; which take as follows:

1. *Arſenick*, is a foſſile Subſtance, conſiſting of much *Sulphur*, and ſome *cauſtick Salts*; it is of three Sorts, the white, or proper *Arſenick*; the yellow, called *Auripigmentum*; and the red, called *Sandaracha*.

2. *Bitumen*, is a Kind of Pitch, or ſlimy Clay; it is very much of the Nature of *Sulphur*, being very inflammable; it is of 2 Sorts, one liquid, which ſwimeth like Oil on Water; the other more hard and compact, is dug out of the Earth.

3. *Ambergreaſe*, is a Kind of *Bitumen*, found in many Places on the Sea-ſhore; it grows hard in the Sun-Beams; the beſt Sort is grey when dry, eaſily ſoftens in the Heat, and appears blackiſh when wet.

4. *Aſphaltos*, this is that ſlimy bituminous Subſtance, of a purple Hue, which is

found in the *Lake of Sodom*, or *Dead-Sea*, in the *Land of Paleſtine*; from whence its Waters are ſaid to ſtink to that Degree, that no Fiſh can live in them, nor the Birds in the Air fly over it, and live.

5. *Naptha*, is another Sort of *Bitumen*, being liquid; but ſomewhat more apt to take Fire, and is more hardly extinguiſhed.

6. *Amber*, is alſo a Kind of coagulated *Bitumen*; though it is evident, its firſt State is ſoft and viſcous, from the Flies, Ants, Straws, *&c.* found in its Texture; it is different in Colour, as white, yellow, and black; is found in ſmall Currents near the *Baltick-Sea*, the *Dutchy of Pruſſia:* It hath an electrick Property; for being rubbed, it will attract Hairs, Feathers, Straws, *&c.*

7. *Petroleum*, or *Oil of Peter*, is of a ſulphureous Nature; it diſtils through the Clefts of Rocks in *Italy*, *Sicily*, and *Provence*; and ſeems to be an *Oil* of ſome *Bitumen*, which the *ſubterranean Fires* have raiſed.

A. Sir, I thank you: I ſhould be glad, in the next Place, to be informed a little of thoſe Bodies, of the *fourth* Head, called *Minerals*.

B. Thoſe are ſuch Sort of *Foſſils*, as are not inflammable, nor ductile, nor to be melted, or liquified; but are hard and brittle, may be reduced to a Powder, or, by Fire, calcined to a Calx; of which, the following are moſt worth Notice:

1. *Marcaſſite*, or *Biſmuth*, is a metalick Matter, white, ſmooth, hard, brittle, ſharp; is of a ſulphureous Nature, like to Tin; it is diſpoſed into Facets, or ſhining Scales, like Pieces of Glaſs; hence called Tin-Glaſs.

2. *Antimony*, is a Mineral, conſiſting of a *Sulphur*, and a Subſtance approaching to that of Metal, containing alſo (as 'tis thought from its emetick Quality) an *acid Salt*; it is found in diverſe Places, in *Tranſylvania*, *Hungary*, *France*, and *Germany*.

3. *Cinnabar*, is a Mineral, conſiſting of a Mixture of *Quick-ſilver* and *Sulphur*, ſublimed together by Means of a ſubterranean Heat, in the ſame Manner as the *Chymiſts* make artificial *Cinnabar*; it is while in the Lump of a browniſh Colour, but when pulverized is of a very high red.

4. *Mercury*, or *Quick-ſilver*, is the moſt wonderful of all Minerals, being Fluid, like Water; the moſt weighty and ponderous of all Bodies; it is abſolutely Opake, admitting none of the Rays of Light through its Compoſition; whence it is ſuppoſed to conſiſt of exceeding ſmall, ſmooth, ſolid, ſpherical, or ſpheroidical Particles of

Matter; whence alſo it becomes extream voluble, and alſo volatile, eaſily evaporating over the Fire. It is commonly found under Mountains (ſometimes alſo running in Mines) in many Places of *Europe*, as *Spain*, *Poland*, *Hungary*, &c.

5. *Chalk*, is mineral Earth, of a bituminous Quality, yet is an *alkali Salt*; is of a ſoft, and friable Texture in many Places; and in others of a hard and maſſy Subſtance, called Quarry; it every where abounds in Hills, and Ridges of Mountains, and other Places.

6. *Coal*; this is a Mineral, conſiſting of *Sulphur* in great Quantities, mixed with a terreſtrious Subſtance; it is a Kind of a *reſinous Bitumen*, of a middle Conſiſtence, not eaſily inflammable, yet will run and melt with Heat; its Texture is not ſoon deſtroyed by Fire, but is thereby at laſt reduced to a Calx, or Cinder; it is dug in great Quantities out of the Earth in *England*, and other Places, and ſerves chiefly for Fuel.

A. Pray how came you to reckon *Mercury* amongſt the Minerals?

B. Becauſe dug out of the Earth, and ſo really a Mineral; and alſo becauſe the beſt Philoſophers rank it with Minerals, its nature approaching nearer thereto, than to that of Metals; of the Number of which ſome make it.

A. Pray what is the proper Nature of Metals?

B. Thoſe Bodies are only called Metals, which are capable of being melted, or put into Fuſion; of being malleated, or drawn out into thin Plates by hammering; and whoſe Subſtance is more ſolid and weighty than any other Bodies.

A. How many, I pray you, of thoſe metalick Bodies do you reckon?

B. They are in Number ſeven, *viz. Gold, Silver, Braſs, Copper, Iron, Tin, Lead.*

A. Pray give me an Account of theſe Metals, and I ſhall be obliged to you.

B. That I gladly will, as follows:

1. *Gold*, is the moſt perfect of all Metals, or Bodies whatſoever, it is the moſt ſolid and compact of any; its Ductility is not only exceeding all others, but vaſtly ſurprizing, as appears by thoſe Inſtances I gave when we diſcourſed of this Property of Bodies; it is ſo pure, when cleanſed from Ore, that Fire will not touch, alter, or diminiſh its Quantity, and is reckoned on this Account the moſt valuable of all Metals: It is found in Mines in various Places of the World; Grains of Gold are alſo found in the Sand of many Rivers; and ſeveral Stones contain Particles of Gold, as *Lapis Lazuli, Lapis Armenus*, &c.

2. *Silver*, is the next pure and perfect Metal to Gold; it is alſo next to it in Ductility, and Ponderoſity; its Particles are moſt like thoſe of Gold, and will therefore mix with Gold in Liquefaction; and in ſhort, is in all Reſpects, but two, ſimilar to Gold: For, 1. Their Colour is different. 2. They require different Mediums to diſſolve them; for Gold requires *Aqua Regalis*, and Silver *Aqua Fortis*, which alſo diſſolves all other Metals: It is found in Mines, generally mixed with other Metals, as Gold, Copper, Lead.

3. *Braſs*, is a Sort of Copper, mixed with *Lapis Calaminaris*, according to *Job* xxviii. 2. *Braſs is molten out of the Stone*; that is, by the Heat of ſubterranean Fire, the Stone is fuſed and tranſmuted into the Subſtance of Braſs: It is dug out of Mines, or Hills, *Deut*. viii. 9. and is alſo factitious, or made by Art.

4. *Copper*, is a Metal, that abounds with *Vitriol* and *Sulphur*; the Ore is found in a Powder, or Stone, in many Mines of *Europe*, but eſpecially in *Sweden* and *Denmark*.

5. *Iron*, is a very porous Metal, compounded of a vitriolic Salt, Sulphur, and Earth, ill digeſted together; it is much harder, leſs ductile, and more impure, than the foregoing Metals. Iron Ore is found in many Mines of *Europe*, in Form of a

Stone, or Marcaſſite. Steel is only Iron purified, and indurated, or hardened.

6. *Tin*, is a malleable Subſtance, ſulphureous, and eaſily put into Fuſion, or melted; it is of a Silver Colour, but more porous and lighter than Silver. It was by *Pliny* called a white Lead. It is found in many Mines, eſpecially in our own Iſland.

7. *Lead*, is a Metal-filled with Sulphur, or a bituminous Earth, which makes it more ſupple and pliant than any other; it is alſo found to contain ſome *Mercury*; it is the moſt groſs and impure of all Metals, and therefore the eaſieſt to be diſſolved: It is found in many Countries, fixed to diverſe Sorts of Stones and Earths, containing ſome Silver, and ſome both Gold and Silver. And theſe are the principal Accounts I meet with concerning the Nature and Production of Metals.

A. Well, *Sir*, I heartily return you thanks; and, if you are not tired with talking ſo long, I ſhould next be glad to hear you on the Subject of the ſixth general Head, *viz. Stones*.

B. No, *Sir*, I am never tired on the Subjects of Mathematicks and Philoſophy; and therefore I will go on to enumerate ſome of the principal *Stones*, and hint to you the particular Properties of each of them.

1. *Marble*, is a curious Subſtance, ariſing from an earthy Juice, well purged, concocted, and digeſted in the great Laboratory of the Earth; a Body very compact and hard, and may be calcined to Powder, but cannot be put into Fuſion.

2. *Alabaſtre*, is a Kind of Marble, but more ſoft and friable, and is cumbuſtible like Lime; but as ponderous and polite as Marble it ſelf.

3. *Porphyry*, is another Species of Marble, various coloured, ſomewhat lighter than Marble, yet very hard.

4. *Flint*, is an exceeding hard Subſtance, generated from the pellucid Particles of Sand compacted together, and indurated; and may be put into Fuſion, whence Glaſs is made.

5. *Chryſtal*, is a very pellucid tranſparent Gem; the moſt pure is found in the Tops of Rocks and Mountains, and dug out of the Bowels of the Earth alſo; it is not coloured, is ſofter than other Gems, and therefore ſhineth not much; it conſiſteth of an aqueous Subſtance, and is therefore eaſily liquefied and converted into Glaſs, ſaith *Cardan*.

6. *Adamant*, or *Diamond*, is in Colour and Figure much like *Chryſtal*, generated in the ſame Manner, but its Hardneſs far exceeds that of all other Bodies; for it will

cut and penetrate the Texture of any of them; it has an electrick Quality, in attracting Straws, Feathers, &c. being warmed by Attrition.

7. *Beryll*, is a Stone, much of the Nature of a *Chryſtal*, of a faint green Colour; found at the Roots of *Mount Taurus*, in the River *Euphrates*, and in the *Indies*.

8. *Smaragdus*, an Emerald of a lovely Green, and of ſo ſtrong a Luſtre, that it ſhineth in the Light of the Sun or Candles; it is very tranſparent, and ſaid to tinge the Air with its Greenneſs.

9. *Carbuncle*, is a precious Stone of a tranſcendent Luſtre; being of a glowing fiery Colour, like a burning Coal, as the Name importeth.

10. *Ruby*, ſo named of its noble red Colour, is the moſt valuable of all precious Stones next the *Diamond*; it is ſaid to be firſt white, and to grow red gradually from a ſanguine Juice, of which it is nouriſhed and generated from at firſt.

11. *Hyacinth*, or *Jacinth*, is a Species of the *Carbuncle*, of a red-lead Colour; it having its Name from a Flower of the ſame Colour.

12. *Amethyſt*, this is near the Nature of an *Hyacinth*, is of a purple Colour, ariſing as it were from a Mixture of red and blue; they are very hard, and the harder the better.

13. *Sapphir* (from the *Hebrew* ספָר, *ſpecious, beautiful*) is a precious Stone of a lovely Azure, or sky-coloured Blue, found in many Places in the *Indies*.

14. *Topaz*, this precious Gem is reckoned to excel among all thoſe which ſhine with a golden Colour.

15. *Sardius*, a Gem called the *Carnelion*, or *Cornelion Stone*, from its fleſhy Colour; the beſt is found in *Sardinia*, whence the Name.

16. *Onyx*, a Gem partly pellucid, ſo called becauſe it expreſſeth the human Nail in Colour and Splendor.

17. *Sardonyx*, is a precious Stone, ſomewhat pellucid, and is thus named, as if made up of a *Sardius* and *Onyx* together; it is diſtinguiſhed moſtly by black, white, and ſanguine Circles.

18. *Chalcedony*, was formerly reckoned a Sort of *Carbuncle*, but is now referred to the *Onyx*; it is very hard, and of a light cloudy Colour through its whole Body.

19. *Achate*, this is an opake Gem, yet ſparkling by reflected Light; and by various coloured veiny Lines, reſembles Trees, Rivers, Animals, &c. beautifully on its Surface.

20. *Jaſper* is, like the *Achate*, opake and of various Hue; but the Green is the more general Colour of this Stone.

21. *Pearls* are Jewels, or precious Stones, bred in the Shells of Fiſh; of which there be various Kinds, not much to our Purpoſe here to recount.

A. But, *Sir*, I think in all your long Catalogue of Minerals and Stones, you have not mentioned the *Load-ſtone*.

B. No, *Sir*, I have not; the Reaſon is, becauſe this, moſt wonderful of all Foſſils, hath always merited a particular Conſideration.

A. Be pleaſed then, *Sir*, to oblige me with a ſhort Account of the Nature and ſome of the chief Properties of this Stone.

B. The *Magnet*, or *Load-ſtone*, is a Mineral found in iron Mines, which is ſomewhat of the Nature of Iron, but is not malleable, nor will it melt, but may be reduced to Powder, or calcined to a Calx; its Particles therefore are more rigid, hard and implicated, than thoſe of Iron. The chief Properties of the *Magnet* are theſe: 1. The *Load-ſtone*, at Liberty, doth always put it ſelf in a Poſition, reſpecting the Poles of the World, and the ſame Parts always tend to the ſame Pole. 2. This Stone doth not preciſely point to the Poles of the Earth, but declineth a little *Eaſtward*, or *Weſtward*, more or leſs. 3. Two *Load-ſtones* placed at a certain Diſtance, approach to, or receed from each other, as they are variouſly placed. 4. *Load-ſtones* do ſo attract each other, as to ſuſtain one another pendent in the open Air, provided the *North* Pole of the one be oppoſed to the *South* Pole of the other. 5. Sometimes a lighter *Magnet* will ſuſtain a heavier one pendent, though a heavier *Magnet* will not ſuſtain a lighter one. 6. It is obſerved, this Virtue of turning to the Poles is not equally ſtrong in all *Load-ſtones*, ſome doing it with greater Celerity than others. 7. There are obſerved ſome *anomalous Load-ſtones*, which ſeem to have more than two Poles, or Points of Direction. 8. The *Load-ſtone* attracteth Iron, as it were another *Load-ſtone*. 9. The magnetick Virtue is communicated to Iron or Steel by the Touch; thus a Needle touched by the *Load-ſtone*, will always keep in a Poſition towards the *North* and *South*. 10. *Load-ſtones* are corrupted if they lie long together, with *North* Pole to *North* Pole, or contrarily; they alſo loſe their Virtue by being made red Hot in Fire, with many other Properties of leſs note.

A. And pray, *Sir*, whence is this Mineral endued with this ſurprizing Virtue?

B. I cannot find any of the Philoſophers can tell the formal Cauſe thereof; it is a Secret yet hid from Man, though he be bleſt with a Diſcovery of its Uſe.

A. Pray what Parts of the Earth are moſt productive of Minerals and metallick Subſtances?

B. Mountains, which ſeem, as it were, deſigned as Matrices for the Generation and Maturation of Minerals and Metals; becauſe in them the moſt uſeful Foſſils are principally found.

A. Pray do Minerals, Metals, Stones, *&c.* grow in the Earth?

B. Undoubtedly: Yea, it is well known that divers Mines when emptied of Stone, Metal, *&c.* have after a while recruited again. Alſo divers ſtony, ſparry Icicles, and other ſtalactical Subſtances, may be daily ſeen engendered from the Exſudations of ſome petrifying Juices out of the rocky Earth in great Caves; as I my ſelf have ſeen in *Oky-hole* in *Somerſetſhire.*

A. Well, but to make an end, what may you mean by extraneous Bodies in the Earth, the Subject of the 7th and laſt general Head?

B. The various Exuviæ of Fiſh, and other marine Animals; ſuch petrified Sea-hedghogs, Gloſſopetræ, or petrified Tongues, Cockles, Oyſter-ſhells, Turbens, Scallops, *&c.* as are found in various Parts and great Depths of Earth, and are to be ſeen in the Cabinets of the Curious.

A. Pray how came thoſe Bodies at firſt intermixed with the Earth?

B. None can certainly tell; it is ſuppoſed at the Deluge, or by ſome general Inundation of the Seas, whereby the Earth was rendered ſoft, and thoſe marine Bodies ſank therein, and were covered over; and by the petrifying Quality of the Earth, in Time, turned into Stone.

CHAP. III.

Hydrography, or the Philoſophy of Water; of the Laws of its Preſſure and Gravity; of the Sea, its Origin, Roundneſs, Extent, Saltneſs and Tides; of the Cauſe of Fountains, Rivers, Lakes, and Baths, with the Properties of their ſeveral Waters.

A. PRAY what is the Original of *Hydrography?*

B. The Word is compoſed of Ὕδωρ, *Water*, and Γραφὴ, a *Deſcription*; and here ſignifies a philoſophical *Deſcription of Water*.

A. You have already deſcribed the the different Diſtinctions of Water on the Earth's Surface, and likewiſe the Cauſe of its Fluidity and Volubility; pray what then remains to be farther conſidered of Water?

B. In the firſt Place we muſt more particularly conſider the Effects ariſing from Fluidity, and the Rules of Motion, called the hydroſtatick and hydraulick Laws of the Gravity and Preſſure of Fluids.

A. Pray what are thoſe Effects you call the hydraulick Laws of *Fluids*?

B. We have not Time to conſider all, the chiefeſt are the following.

1. The Surface of a Fluid contained in a Veſſel abiding free, will become plain or parallel to the Horizon: Thus the Surface AB, of the Fluid CD, will be parallel to the Horizon HO.

2. The upper Parts C preſs the lower Parts D, which ſuſtain them; and this Preſſure is always proportional to the Height of the Fluid AE.

3. This Preſſure on the lower Parts, from the Gravity of the ſuperincumbent Liquid, exerts it ſelf every Way, and every Way equally.

4. In ſeveral Tubes, having a Communication with each other, as ABCDEF, whether equal or unequal, ſtreight or oblique, a Fluid will riſe to the ſame Height GI in all. *Fig*. XXXIV.

5. When Liquids of different Gravities are contained in the ſame Veſſel, the hea-

vieſt lies at the loweſt Place, and is preſſed by the lighter, in proportion to the Height of the lighter.

6. The Bottom EF, and Sides AEBF, all round a Veſſel, are preſſed by the Parts of the Liquid contained which immediately touch them; and that in Proportion to the Height of the Liquid, not at all regarding its Quantity.

7. A ſolid Body immerſed in a Liquid, is preſſed by the Liquid on all Sides; and that Preſſure increaſes in Proportion to the Height of the Liquid above the Solid. Bodies very deeply immerſed are, as it were, equally preſſed on all Sides.

A. Pray, *Sir*, what do you call the hydroſtatick Laws of *Fluids*?

B. Thoſe which relate to their Gravity, and their Action on Solids immerſed therein; the Principal of which here follow.

1. Any Body which is heavier than an equal Bulk of the Liquid into which it is immerſed, will ſink or deſcend therein.

2. If the Body be lighter than an equal Bulk of the ſaid Liquid into which it is immerſed, it will aſcend to the Top or ſwim.

3. But, ſuppoſe the Body be equal in Weight with an equal Bulk of the Liquid, it

Plate XI Page 248

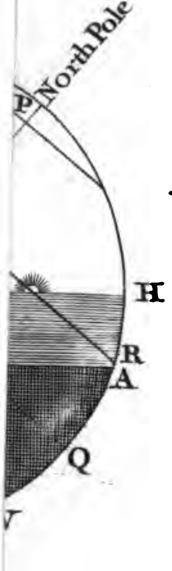

Fig: XXXI.

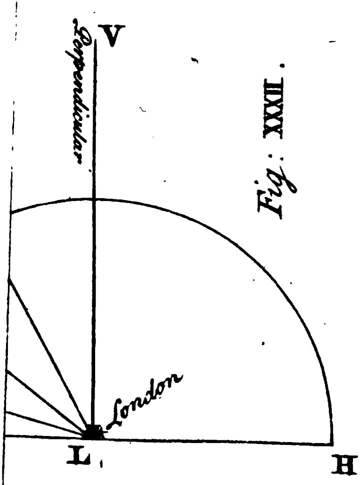

Fig: XXXII.

it will neither aſcend or deſcend, but remain ſuſpended in the Liquor where-ever it is placed.

4. All equal Solids, but of different ſpecifick Gravities, being immerſed in the ſame Liquid, loſe equal Parts of their Weight.

5. A Liquid acquires the ſame Weight which the immerſed Solid loſes.

6. The immerſed Parts of Bodies ſwimming on the Surface of the ſame Liquor, are to each other as the Weights of the Bodies.

A. And, pray, how do you prove theſe Laws, and what are their Uſe?

B. They are founded on various Experiments; and their Uſe is to diſcover the different Weights or ſpecifick Gravities of Liquids and Solids, which is not only a very great and uſeful, but alſo a very pleaſing and delightful Part of natural Philoſophy.

A. Pray how do you find or eſtimate the ſpecifick Gravities of Solids?

B. Thus, by the hydroſtatick Balance S, *Fig.* XXXV, let there be prepared a Glaſs-Veſſel of Water E, and another Veſſel D, whoſe Weight in Water muſt be preciſely equal to that of the Weight C. Now the Weight C being affixed to the Scale A, the Solid, whoſe ſpecifick Gravity is deſired, being firſt weighed in Air, muſt then be put into the Veſſel D, which is then affixed to the Scale B, and immerſed into the Veſſel of Water; then put Weights into the Scale B 'till there be a juſt Equipoiſe. Now from its Weight in Air, ſubduct its Weight in Water, and with the Remainder, divide the Weight in Air, the Quotient will be the Ratio of its ſpecifick Gravity; and thus the Ratio's or Proportion of the ſpecifick Gravities of ſeveral Bodies may be found.

A. As to the Manner of weighing thoſe Bodies, it ſeems pretty eaſy to be apprehended from the *Figure*; but as to computing the Ratios, I believe I could better underſtand that by Example.

B. Why then I will give you one: Suppoſe you take a Piece of Lead and a Piece of Ivory, each weighing 60 Grains in Air, but weighing them ſeparately in Water, you find their Weights therein to be $54\frac{1}{4}$ and 29; now the Deficiency of theſe Weights are $5\frac{3}{4}$, and 31; by each of theſe Numbers divide 60, the Weight in Air, the Quotients will be 11 and $1\frac{2}{3}$ nearly: Therefore the Ratio or Proportion of the Weight of Lead to that of Ivory, is as 11 to $1\frac{2}{3}$; that is, Lead is almoſt 7 Times heavier than Ivory.

A. Sir, I perfectly apprehend you now, and thank you; pray do you eſtimate the ſpecifick Gravities of Liquids after the ſame Manner?

B. They

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An ESTIMATE of the ſpecifick Gravity of SOLIDS.

In Air 60 Grains.	In Water.	Dim.	Prop.
Crude Mercury	$55\frac{3}{4}$	$4\frac{1}{4}$	14
Lead	$54\frac{1}{4}$	$5\frac{3}{4}$	11
Copper	53	7	8
Braſs	53	7	8
Crude Tin	53	7	8
Regulus of Antimony	52	8	$7\frac{1}{2}$
Regulus of Steel and Copper	52	8	$7\frac{1}{2}$
Block-Tin	52	8–	$7\frac{1}{2}$
[illegible]	$51\frac{1}{2}$	$8\frac{1}{2}$	7 fere
Gall	2	58	$1\frac{1}{29}$
Gentian	0	0	$0\frac{60}{75}$
Peruvian Bark	0	0	$0\frac{120}{153}$
Oak	0	0	$0\frac{60}{86}$
Fir	0	0	$0\frac{60}{108}$

An ESTIMATE of the ſpecifick Gravity of LIQUIDS.

The Weight of a Piece of Lead.	Weight.	Dim.	Prop.
In Air	455	0	0
Oil of Vitriol	379	76	$5\frac{75}{76}$
Herm. Spirit of Nitre	383	72	$6\frac{2}{7}$
Spirit of Nitre, with Oil of Vitriol	396	59	$7\frac{4}{5}$
Spirit of com. Nitre	397	58	$7\frac{23}{29}$
Spirit of Nitre Bezoartick	397	58	$7\frac{23}{29}$
Double Aquafortis	400	55	$8\frac{1}{5}$
Spirit of Vitriol	406	49	$9\frac{1}{4}$
Spirit of Salt, with Oil of Vitriol	408	47	$9\frac{3}{4}$
Tincture of Coral	421	34	$13\frac{1}{3}$
Spirit of Wine	$421\frac{1}{2}$	$33\frac{1}{2}$	$13\frac{1}{2}$
Oil of Turpentine	$422\frac{1}{2}$	$32\frac{1}{2}$	$13\frac{1}{2}$
Spirit of Wine Rect.	$423\frac{1}{2}$	32	14
Boil'd Water	424	31	$14\frac{2}{3}$

B. They are eſtimated thus: Take a Piece of Lead, which ſuppoſe to weigh 455 Grains; then the ſame weighed in Oil of Vitriol will be found no more than 379, and in common Water 414 Grains. The Diminution in the firſt Caſe is 76, in the latter 41 Grains; now divide 455 by 76 and 41, and you will have the Quotient 6 and 11 very nearly: Wherefore the Gravity of common Water is to the Oil of Vitriol as 11 to 6; that is, almoſt as heavy again: Do you underſtand me?

A. Yes, *Sir*, very well: I only wiſh I had ſuch a Pair of Scales as are fit for this Purpoſe; for then I ſhould take a deal of Pleaſure in making thoſe Kinds of Experiments.

B. Sir, you may eaſily acquire a Pair; and 'till then, I can lend you a *Synopſis* of an Eſtimate of the ſpecifick Gravity of various Solids and Liquids, which I have taken from Dr. *Quinſey*, if you think it worth your Peruſal.

A. Sir, I am very much obliged to you for ſo extraordinary a Piece of philoſophical Curioſity: And, pray, have you nothing very remarkable to be obſerved from the foregoing Laws of the Preſſure of *Fluids*?

B. Yes, more than I can here exemplify to you; however that you may be ſomewhat the wiſer for them, learn their Uſe in the following Inſtance: Suppoſe AB (*Fig.* XXXVI) a Ciſtern or Tube filled with Water always even to the Brim, as at S; now let there be any Number of Holes DECFG made through the ſame, the Water ſpouting through each of them, will fall to an horizontal Diſtance, which is double to the Diſtances of thoſe Holes from the Periphery of a Circle AKB, deſcribed about the Length of the Tube, as a Diameter.

A. If this be the Caſe, I eaſily perceive why, in the Scheme, the Water ſpouting from the middle Hole C, falls fartheſt from the Tube; for according to you, the Diſtance BQ, to which it falls, is equal to twice CK, that is, equal to the Height of the Tube AB; and as this CK is the fartheſt Diſtance from the Circle, the Double thereof BQ muſt needs be greater than the Double of any other Diſtance, and therefore its Water ſpouts the fartheſt.

B. You take the Reaſon of the Thing very well; you may alſo farther obſerve, that from two Holes EF, equally diſtant above and below the central Hole C, the Water will ſpout to an equal Diſtance BP, the Double of EL or FI, which are equal Diſtances from the Circle: Alſo the Water from G will ſpout to O, which is double the Diſtance GH; and the Water from D will ſpout to N; for BN is double the Diſtance DM from the Circle.

A. I underſtand you thoroughly concerning this; have you any Thing elſe to obſerve of the Preſſure of *Fluids*, pray?

B. One Thing amongſt many I could name is this: That, let a Body be ever ſo heavy, yet it may be made to ſwim in Liquids.

A. This is very ſurpriſing indeed! What can Lead or Gold be made to ſwim in Water, *Sir?*

B. Yes, by knowing their ſpecifick Gravities: Thus, becauſe the ſpecifick Gravity of Gold is to that of Water, as 19 to 1; therefore if you hold a Guinea to the Bottom of a Tube of equal Diameter (ſo as no Water can get in) by Means of a String, then put the Tube down into the Water above 19 Times the Thickneſs of the Guinea in Depth, and letting the String go, the Guinea will not ſink, but ride ſuſtained by the Preſſure of the ſubjacent Water, which now is ſtronger than the Power of Gravity in the Guinea; and thus you may make any Body ſwim, how large, ſolid and weighty ſoever.

A. Well, I thank you for theſe general Inſtructions concerning the Nature and Effects of *Fluids:* And now, *Sir*, if you pleaſe, we will divert our Diſcourſe to the Contemplation of Water in particular; and firſt we will begin with the Waters of the Sea: What therefore do you find is known concerning their Extent, or what Proportion do the Superficies of the Sea bear to thoſe of the dry Land?

B. This is not preciſely known: I remember I once calculated the Proportion of Water and Land, as they are repreſented on my terreſtrial Globe of 16 Inches Diameter, and found it to be ſomewhat more than ⅔, but how much I cannot juſtly ſay, having loſt my Notes of that Particular at preſent.

A. Pray how came the Earth to be covered over, ſo far the greater Part, by Water?

B. Thus it pleaſed God in the Beginning to order it; for wiſe Ends no doubt: The Waters of the Earth muſt neceſſarily riſe to the Surface thereof, as being ſpecifically lighter than Earth; and then it was as neceſſary there ſhould be large Cavities therein for Receptacles to contain them, otherwiſe they would equally have overſpread all the Superficies of the Earth, and ſo have rendered it utterly uninhabitable by Mankind.

A. I underſtand the Figure of the whole Earth is round, and conſequently the Superficies of the Sea muſt be ſo too, which I think you impute to the Action of Gravity or Power of Attraction in the Earth, do you not, *Sir*?

B. Yes, the Center of the Earth being the common Center of Gravity, and the Nature of Fluids being ſuch, that they equally yield to equal Powers, and the Power of Attraction being every where equal at equal Diſtances from the Center, it follows the ſuperficial Parts of Water will every where conform themſelves to an equi-diſtant Situation from the Center, and conſequently will form the Surface of a Sphere ſo far as they extend.

A. Pray, *Sir*, is the Sea higher than the Earth or Land, as it ſeems to be?

B. Nothing leſs; for by the Power of Gravity all Things conform to a ſpherical Surface, in which no one Part is higher than another; beſides Fluids preſs every Part equally, and therefore would ſoon overflow the Shores were they really loweſt.

A. How comes it to appear ſo, pray?

B. This reſults from the Fallacy of Viſion, whereby all Objects, and the Parts of Land as well as Sea, the farther they are from us, the higher they appear; thus in Pieces of Perſpective, the Parts are all placed higher above the Ground Line, as they are farther diſtant from it: The Reaſon of all which is eaſy from *Opticks*.

A. Pray, *Sir*, is the Depth of the Sea known?

B. Varenius affirms, the Depth or Profundity of the Sea is in ſome Places unfathomable; and in other Places is very various, being in ſome Places $\frac{1}{20}$, $\frac{1}{5}$, $\frac{45}{100}$, 1 $\frac{1}{10}$, 2 $\frac{1}{10}$, 4 $\frac{1}{2}$ *Engliſh* Miles, and in ſome Places deeper, and is much leſs in Bays than in Oceans. The Depths of the Sea bear great Analogy to the Height of Mountains on the Land, ſo far as is hitherto diſcovered.

A. Are you able to ſay whence the Saltneſs of the Sea doth ariſe, pray *Sir*?

B. It is very rationally judged to ariſe from great Multitudes both of Mines and Mountains of Salt, diſperſed here and there in the Depths of the Sea: The Salt being continually diluted and diſſolved by the Waters, the Sea becomes impregnated with its Particles throughout; and for this Reaſon the Saltneſs of the Sea can never be diminiſhed.

A Pray what is the Uſe of this Salt Property of the *Sea*?

B. The *Saltneſs* of the *Sea* preſerves its Waters pure and ſweet, which otherwiſe would corrupt and ſtink like a filthy Lake; and conſequently none of Myriads of Creatures which now live therein, could then have Being; From hence alſo the Sea Water becomes much heavier; and therefore Ships of greater Size and Quantity may be uſed thereon. Salt Water alſo doth not freeze ſo ſoon as freſh Water, whence the Seas are more free for Navigation.

A. I remember *Solomon* obſerves, that though all the Rivers run into the Sea, yet the Sea is not full, or doth not increaſe; pray is there any aſſignable Reaſons for it?

B. Yes; there are two Reaſons why the Sea doth not increaſe. 1. Becauſe Waters return from the Sea by ſubterranean Cavities and Aqueducts, through various Parts of the Earth. 2. Becauſe of the Quantities of Vapours raiſed from the Sea, and falling on the Land, doth only cauſe a Circulation, but no Increaſe of Water. It hath been found by Calculation, that in a *Summer*'s Day there may be raiſed in Vapours from the *Mediterranean* 5280000000, or 5280 Million of Tuns of Water; yet this Sea receiveth not from all its nine great Rivers above 1827000000, or 1827 Millions of Tuns *per* Day, which is but a third Part of what is exhauſted in Vapours; wherefore we may rather wonder the Sea is not leſſened than increaſed.

A. Well, I am wonderfully pleaſed with theſe Accounts of the general Properties of the Sea: But, pray, what do you ſay to that moſt obvious and wonderful *Phænomenon*, the Tide, or Flux and Reflux of the Sea?

B. It is now very well known, that the Tides are cauſed by the Attraction of the Moon, and are ſometimes encreaſed by the At-

Attraction of the Sun conſpiring therewith, as in Conjunctions, or new Moons, and thoſe we call *Spring Tides*; ſometimes the Sun's Attraction acts counter to the Moon's, as in the Quadratures, and then the Tides are leſſened, and are what we call *Neap-Tides.*

A. Pray be ſo good as to illuſtrate the *Doctrine of the Tide* by a Scheme.

B. I will: Suppoſe then C be the Earth, ſurrounded by Water PTN, M the Moon in Conjunction with, and O in Oppoſition to the Sun in S, and in her Quadratures from the Sun in Q: Now it is plain the Part of the Ocean T, to which the Moon M is perpendicular, will gravitate to the Moon more than any other Parts in the *Hemiſphere eTn*; and therefore the Water in that Part will become lighter than uſual, and ſo will tumify and riſe up towards the Moon. On the contrary, the Water in N, being moſt remote from the Moon M, will be leſs attracted, or gravitate leſs towards the Moon than any other Parts of the Land or Sea in the *Hemiſphere eNn*; and therefore will keep at fartheſt Diſtance from the Moon, or, which is the ſame Thing, it becomes lighter than uſual, and tumifies on the Part N, contrary to the Moon M. By this Means the Ocean muſt of Neceſſity conform it ſelf to an oval Figure, whoſe longeſt Diameter is TN, and the ſhorter *en*: Now becauſe the Tides at T and N, are exiſtent both at the ſame Time, and oppoſite to each other, it is evident, they following the daily Courſe of the Moon, that they muſt conſtantly ſucceed each other under every Meridian at the Diſtance of 12 Hours Time, and therefore twice each Day as we ſee they do: Do you apprehend me ſo far, pray?

A. Yes, very well, pray proceed.

B. Then the reſt will be ſtill eaſier: For ſuppoſe (as Sir *Iſaac Newton* has) that the Attraction of the Sun be to that of the Moon at our Earth, as 1 to $4\frac{4815}{10000}$, or nearly, as 1 to $4\frac{1}{2}$; that is, as 2 to 9. But *Domkius* has ſince made it to be as 1 to $5\frac{10248}{100000}$, or as 1 to 5, or more nearly ſtill, as 10 to 51 (whoſe Numbers I ſhall uſe) I ſay, ſuppoſing this be the Proportion of the Sun and Moon's Power of attracting the Waters of our Seas, then it follows, that when the Sun and Moon are in Conjunction, the Waters at T and N will be attracted by both theſe Powers jointly; but, when the Moon is in Square to the Sun, that is, when thoſe Luminaries are in M and Q, then the Power of the Sun in Q acts contrary to that of the Moon in M; and then the Waters in T and N, are raiſed only by the Difference of thoſe Powers; ſo that the *Spring Tides* will be to the *Neap Tides*, as the Sum to the Difference of thoſe Powers; that is, as 6 to 4, or as 61 to 41. So that, if the Sun

Earth doth afterwards to the Radicle, or Earth Root it ſelf.

B. Yes, it doth ſo; and having enabled the Earth Root to ſhoot into the Earth in order to procure its own Nouriſhment, it is then, by Means of the Seed Root, turned to the Uſe of the Pluma; cauſing it alſo to ſprout upwards, in Order to become a Trunk hereafter.

A. Pray what does become of thoſe Seed Lobes AB, when the Earth Root no longer requires their Uſe?

B. They are, in moſt Seeds, carried upwards with the Pluma out of the Earth, after which they compoſe the Seed Leaves, as they are called, as in *Cucumbers* and *French Beans*, we ſee them.

A. What is the Uſe of thoſe Seed Leaves to Plants?

B. The Effects and Uſes of theſe Seed Leaves (ſaith the learned *Malphigi*) are ſo Neceſſary, that if they are pulled off, the Plant will not grow; or if it ſhould any way increaſe, it won't be compleat, but always defective. The Learned are divided as to their particular Uſes to Plants.

A. Well, pray, in the next Place, pleaſe to let me know particularly in what Manner the Root of the Plant procures Nouriſhment for its Growth and Increaſe?

B. In Order to this, I muſt ſhew you the Make and Conſtruction of the Root, and, as it were, anatomize the ſeveral Parts to your View; and then point out their Uſes. To this End, I ſhall chooſe two Roots, *viz.* a Root of *Wormwood*, as *Fig.* XXXIX, and a *Horſe-Radiſh* Root, *Fig.* XL; in each of which, T repreſents the Root cut tranſverſly as it appears to the naked Eye: The other great quadrantal Figures, are each a Quarter of the aforeſaid Section T, magnified to the Sight by a *Microſcope*; which thus inlarged, ſhews the various organical Parts, of which it is compoſed, and by which Vegetation is performed.

A. And does this Glaſs, indeed, thus magnify and inlarge the ſmall Section T? What wonderful Diſcoveries have been reſerved for this curious and inquiſitive Age! Pray deſcribe to me the different Appearances of thoſe magnified Sections.

B. I will in the following Order. 1. A*b* is the Skin or Rind, or outward Membrane including the Root. 2. From A to C in the *Wormwood* Root is the Bark, which is a membranous Subſtance, conſiſting partly of a great Number of little Bladders or Veſicles BBB; the ſame is repreſented by AB in the *Horſe-Radiſh* Root: It alſo conſiſteth in Part of a lignous or woody Subſtance, as from B to L in the Root laſt named. 3. The Wood of the Root is all that Part between B and E in the *Horſe-Radiſh* Root; and from CC, to the very Center in the *Worm-*

Wormwood Root. 4. The Wood of the Root conſiſteth alſo of two different Subſtances, *viz.* a lignous One, properly the Wood, as EEE; and a parenchymous One, like that of the Bark, as DDD, inſerted regularly between the Portions of Wood; theſe are very diſtinct in the *Wormwood* Root, but in the *Radiſh* Root, and in ſeveral others, they are not ſo viſible. 5. In the Wood you ſee the Orifices of ſeveral Tubes, or hollow Veins *aaaa*, which are the Mouths of Air Veſſels. 6. From G to E, in the *Radiſh* Root, is another little Circle of Veſſels, like thoſe of the Bark. 7. *Laſtly*, from E to the Center, in the *Radiſh* Root, is the Pith, which conſiſteth of the ſame parenchymous, or ſpongy Subſtance of Bladders, as doth the Bark, and Part of the Wood; but the Pith is not common to all Roots, as you ſee there is none in the *Wormwood* Root.

A. And, pray, what is the Uſe of the ſeveral Parts of the Root now deſcribed?

B. The Bladders in the Bark render it a ſpongy Subſtance, which therefore is fit to imbibe and ſuck up the watery Parts of the Soil, which are impregnate with the Principles of vegetable Life and Growth: This impregnated Water imbibed by the Bark is what we call the *Sap*; the Skin of the Root ſerving as a Filtre, to ſtrain and purify it at its firſt Entrance. 2. The *Sap* thus ſtrained and imbibed, doth ferment in the Subſtance of the Bark, whereby it becomes farther prepared, and ſo doth more eaſily inſinuate it ſelf into the parenchymous Subſtance of the Root; whereupon, partly by the Appulſe of freſh *Sap*, and partly by the pulſive Motion of the tenſed Bladders of the Parenchyma, the *Sap* is forced thence into the other Parts of the Root; and is ſtill more and more ſtrained in its Paſſage from Bladder to Bladder. 3. The *Sap* thus diſtributed through the whole Root, doth ſupply its organical Parts with thoſe Principles of Nouriſhment which every one requires; and thus the Root, by the conſtant Application of thoſe nutricious Principles, receives its Increment, Solidity and Growth, or vegetative Life and Motion, in every Part.

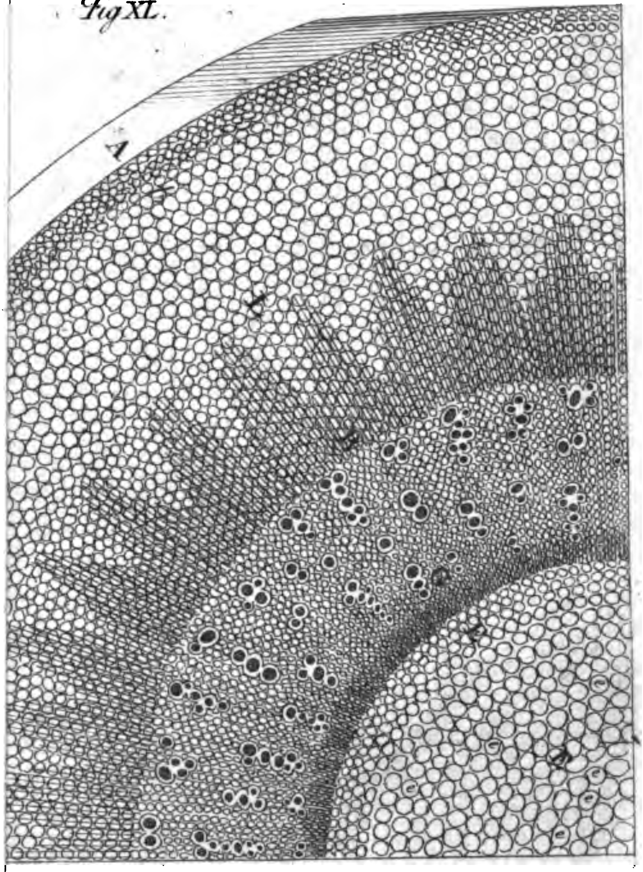
A. Pray, to what end, do thoſe you call Air Veſſels ſerve?

B. In them is contained a proper Kind of vegetable Air or Vapour, which ſerveth to ferment the *Sap* now entering the lignous Part, the better to qualify it for Aſſimilation, or uniting therewith.

A. Why, I pray, do the Roots of ſome Plants yield a milky Juice or Liquor, and others a clear watery one, when cut?

B. Becauſe that in each Root, the Fluid or Liquor of each organical Part is made chiefly by different Filtration of the *Sap* through

Fig XL.



through the Sides thereof; therefore thoſe which ſtrain more freely the aqueous or watery Part of the *Sap*, contain a Lympha or clear Water, and are hence called *Lymphæducts*; and where theſe are moſt numerous in Roots, ſuch Roots when cut will bleed a *Lympha*. As on the other Hand, thoſe Veſſels, which are diſpoſed to admit the oily or balſamick Part of the *Sap* moſt copiouſly, are called *lactiferous Veſſels*; and Roots, which contain a great plenty of thoſe, will when cut bleed a milky, oily or balſamick Liquor.

A. When the Root is thus formed, and inſtructed with all its ſeveral Organs of Vegetation, as you have now related; pray which is the next Step which Nature takes in the Production of the Plant?

B. The Root being now become the Procurator for the future Plant, doth by extracting from the Earth, by its ſucciferous Veſſels, proper vegetable Juices and Aliment, adminiſter or communicate the ſame to the *Pluma*, or *Seed Plant* (ſuſtained 'till now from the Subſtance of the Seed by the Seed Root, or Seed Leaves) and thereby cauſeth it to ſhoot forth vigorouſly and increaſe, and gradually to ſwell out or unfold all its Blades, Branches, Budds, Leaves, Flowers and Seeds again, from various Parts of its Stalk or Trunk.

A. Then, I ſuppoſe, the ſame Mechaniſm, or Apparatus of organized Parts, is continued from the Root to the Trunk or Stem of the Plant, for the Communication of this vegetable Suſtenance; is it not?

B. Yes; and that you may ſee it is ſo, I have taken *Fig.* XLI from Dr. *Grew* for your Satisfaction: In which, T repreſents one Quarter of a Section of a hazel Branch as it appears to the Eye; AGB is the ſame as it appears through a good *Microſcope*; wherein AB is the Skin; ABCD the Bark; QQQ the Parenchyma of Bladders, or Sap Veſſels; HI a Ring of a ſpecial Sort of Veſſels; PP common Sap Veſſels; CDEF the lignous Subſtance, or Wood, of three Years Growth; KLFE the Wood of two Years; MNEF the Wood of the firſt Year; XX the parenchymous Inſertions; O the Pith full of Veſicles; the black Parcels are the ſolid Wood; and thoſe numerous Holes appearing all over the ſame, are the Mouths of Air Veſſels: Thus you ſee the organical Conſtitution of the Stalk or Trunk, is the ſame with that I before ſhewed in the Root.

A. It is ſo, indeed, and I am ſurprized to ſee ſuch wonderous Contrivance and Analogy in the Organization of Vegetables! But, pray, go on.

B. The

Hazel Branch
cut transvesly

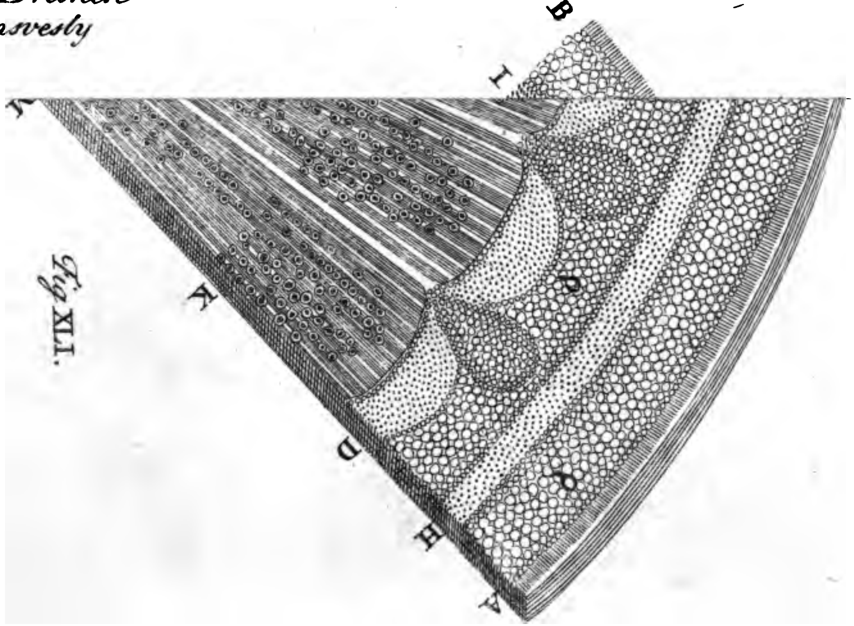


Fig XLI.

B. The nutricious *Sap* aſcendeth the firſt Year of a Plant's Growth by the Veſſels of the Pith; after which it becomes dry, and ſo continueth. 2. The next Part, through which the *Sap* riſeth, is the Wood, by the Air Veſſels, and that only in the Spring. 3. The third Part, by which it aſcends, is the Bark, as beforeſaid, the greateſt Part of the Year; and this is the general Theory of the Motion of the *Sap*.

A. But, ſince both Root and Branch contain Air Veſſels, pray in what Part of the Plant doth the Air firſt enter it?

B. The chief Entrance of Air is at the Root, along with the *Sap*; but it alſo enters more or leſs at the Trunk, Leaves, *&c.* Parts of the Plant: The Air, or airy Part of the *Sap*, being thus raiſed in its proper Veſſels, is filtred through the ſame into the Veſicles of the parenchymous Inſertions in the Wood; and thus is diſtributed through all the Parts of the Plant or Tree.

A. Pray why are the Stalks of ſome Plants hollow within?

B. Partly for the more expedient Ripening of the Fruit or Seed, which is better effected by a more plentiful Supply of Air by theſe hollow Trunks; and partly for the better determining the true Age of the Plant; for the Air in this Hollow, by drying up the *Sap*, ſhrinketh the *Sap* Veſſels ſo far as to hinder the Motion of the *Sap* therein; whence the Plant muſt periſh of Courſe: Hence it is, that the greater Part of annual Trunks are hollow.

A. Pleaſe next to ſay, whence the Form or Figuration of the Trunks of Plants and Trees proceeds?

B. Chiefly from the Air in the Air Veſſels: Thus almoſt all Shrubs have a greater Number of Air Veſſels, and thoſe of a ſmaller Size; which therefore moſt eaſily yielding to the magnetick Attraction of the external Air, do conſequently ſpread much abroad: By which Spreading the Air Veſſels do ſooner, and more eaſily ſtrike into the Bark, and ſo produce collateral Budds and Branches, and that upon the firſt Riſing of the Plant from the Root; and thus it becomes a Shrub: But, if the ſaid Air Veſſels are very large, as in Oak, Walnut, Elm, *&c.* they will not ſo eaſily yield or ſhoot out collaterally; and ſo the Trunk grows up taller and more entire.

A. Pray why do ſome Trees run up ſo very ſlender, and others ſo very thick and big?

B. This is from the Poſition of the Air Veſſels; for where they lie moſt circular round the Center, in Form of Rings, as in Elm and Aſh, there the Tree in proportion grows more tall and taper, and leſs thick: But the ſaid Veſſels ſpread more broad, and are poſtured in Lines from the

Center, as in Oak, *&c.* then the Tree grows very thick; in this Caſe the diametrical Growth of the Wood being more promoted than in any other: For which general Reaſon alſo Trees grow round or angular.

A. Pray how comes it to paſs, that ſeveral Stalks of Plants have Joints or Knots? And what is their Uſe?

B. Becauſe in forming the Branch or Blade, both the cortical and lignous Subſtance thereof are, upon their ſhooting forth, divaricated from their perpendicular Poſture, to a croſs Poſition, and as they with the other grow and thrive together, they bind and throng each other into a Knot. The Uſes of Knots are two, *viz.* for ſtrengthning the Stem; and for finer Growth; for the Knots ſerve to ſtrain and tranſmit the Juices more refined to the upper Parts, and to the Fruit.

A. How do you account for the Production and Texture of the Leaves?

B. The Parts of the Leaf are ſubſtantially the ſame with thoſe of the Branch; its Skin is the Continuation of that of the Branch; the Fibres or Nerves diſperſed through the Leaf, are only Ramifications of the Branch's Wood, or lignous Body; the parenchymous Subſtance, which lies between the Fibres, is nothing but the Continuation of the cortical Body, or Subſtance of the Bark, ſpread through the ſame.

A. Pray what is the Uſe of Leaves?

B. Firſt, for Protection which they afford to each other, and to the Flower in the Bud; as alſo to the Fruit it ſelf in ſome Plants. *Secondly*, for Augmentation; for the Capacity for the due Spreading and Ampliation of a Tree or Plant are its Leaves. *Thirdly*, they ſerve to the greater Purity and Preparation of the *Sap*; the groſſer Parts of which, are retained in the Leaves, while the more elaborate and eſſential are ſupplied to the Flower, Fruit, and Seed, as their proper Aliment. *Fourthly*, They ſerve to Perſpiration; for thoſe Orifices, obſerved to be in Leaves, perform the ſame Functions in Trees as the Pores of the Body do in Men; that is, to cauſe an inviſible Perſpiration in Plants.

A. Pray what do you obſerve concerning the Flowers of Plants?

B. In the Flower may be obſerved: 1. The Empalement, or Calyx, or the Cup, which containeth the Flower, and is deſigned for the Guard and Security of the other Parts of the Flower. 2. The Foliation, or Compoſure of Leaves, which are of divers Forms and Colours; whoſe conſtituent Parts are the ſame as thoſe of the Leaves, *viz.* Skin, Parenchyma, and Air, and Sap Veſſels. 3. Within the Foliage ſtands the Attire; that is, thoſe fine upright Stems with their Apices, and the Stile in the very

Middle of all; and theſe are the general Parts of which the Flower doth conſiſt.

A. Pray can you tell the Uſes of thoſe ſeveral Parts of the Flower?

B. The Empalement, as I ſaid, is for the Security of the Flower in Embryo, and afterwards for the Support of the Foliage, to keep the Leaves of the Flower in due and decorous Poſture, which would otherwiſe hang uncouth and taudry, as a Lady without her Bodice. The Foliage, or Leaves of the Flower, defend the Attire, and in ſome Plants the Fruit; it alſo ſerves for the further Refining and Separation of proper Parts of the *Sap* for the perfecting the Seed. The Attire is an Ornament and Diſtinction in Flowers. It ſupplies alſo divers Kinds of ſmall Animals with Food, which harbour therein; that is, in the Hollowneſs of the Stile. *Laſtly*, it is ſuppoſed, it alſo ſerveth as a Male Sperm to impregnate and fructify the Seed.

A. What is the Nature and Compoſition of Fruit, I pray you?

B. The general Nature and Compoſition of all Fruit is one and the ſame; that is, their eſſential and truly vital Parts are in all the ſame; and but the Continuation of thoſe which I have already obſerved to you do conſtitute the other Parts of the Plant. But, by the different Conſtitution and Textures of theſe Parts, divers conſiderably different Fruits reſult, as Apples, Pears, Plumbs, Nuts, Berries, *&c.*

A. Pray what are the particular Parts which compoſe thoſe different Fruits?

B. The Apple doth conſiſt of theſe four, *viz.* The Pilling, the Parenchyma, Branchery and Coar. The Pear hath five diſtinct Parts; the Pilling, Parenchyma, the Branchery, Calculary and Acetary. The Plumb (to which the Cherry, Apricot, Peach, *&c.* may be referred) conſiſts of four Parts; the Pilling, Parenchyma, Branchery and Stone. The Berry conſiſteth of four Parts; the Pilling, the Parenchyma, Branchery and Seed. The Nut conſiſteth of three Parts; the Cap, the Shell and Pith. All which are largely treated of by Dr. *Grew* in his *Anatomy of Plants.*

A. Pray (to be ſhort) what are the principal Uſes of Fruit?

B. The Uſe of Fruit is two-fold: For, *firſt*, it ſerveth Man (and I may ſay Beaſt) as a delicious and pleaſant Meat or Food; beſides the various Purpoſes of Medicine. *Secondly*, It ſupplies the Seed with a due and moſt convenient *Sap*; the Fruit doing the ſame Office to the Seed, as the Leaves do to the Fruit, *viz.* that by a due Purification and Exaltation of the *Sap*, the Seed may obtain its Perfection.

A. Pray, what is the Seed in its State of Generation?

B. As the Original, ſo the ultimate End and Perfection of Vegetation is the Seed. How it hath been in its State adapted to Vegetation we have already ſeen. Its State of Generation is as follows: The *Sap*, having in the Root, Trunk and Leaves, paſſed divers Concoctions and Separations, is now at laſt, in ſome good Maturity, advanced towards the Seed. In the Fruit, as was ſaid, it is ſtill farther prepared, and the more eſſential Part is tranſmitted into that particular Part of the Branchery, called the *Seed Branch*; which, becauſe it is a good Length, and very fine, doth yet farther maturate the *Sap* in paſſing through it: In this mature State it is conducted through the Seed Branch into the Coats of the Seed, as into the Womb. The meaner Part of the *Sap* to the outer Coat, the more fine is tranſmitted to the inner Coat, where it is farther prepared by Fermentation; and thence is filtred through a fine Skin into the inmoſt Part, or Concavity of the old Seed, and there becomes a Liquor apt for the Subſtratum of the future Embryo Seed: And how that is particularly perfected would be long to relate, and, perhaps, not exactly known to any; wherefore I ſhall deſiſt relating any Thing farther on this Head.

A. But, pray *Sir*, before you quite diſmiſs the Subject of Plants, pleaſe to let me know what you think of Muſhrooms, and thoſe fungous Excreſcences adhering to the Sides of Trees?

B. Muſhrooms, Moſs, and other fungous Subſtances, are a ſpurious Kind of Plants; or which may be called excrementitious Plants; ſince they ariſe intirely from the Bodies of other Plants, or from a Kind of viſcous Mucilage of the Earth: They grow indeed, and have Roots, ſome inſerted into the Fibres of the Plant producing them, as *Miſletoe* is radicated into the Fibres of the Oak; and *Moſs* to the Fibres of the Barks of Trees. Muſhrooms ariſe from various Matters in Earth or Wood, and are found to conſiſt of a vaſt Bundle of Fibres, proceeding from the Subſtance on which they grow; theſe make the Stalk, and thence divaricating ſpread and extend themſelves into a ſpherical Canopy, or Head, which contains a ſucculent Parenchyma; on the under Part of which, I am apt to think, the Seed may be produced (though none hath hitherto been ſeen) which being wafted about by the Wind, falls in divers Places of the Earth, and there takes Root and grows: Thus *Moſs* undoubtedly bears Seed, by which the various Sorts thereof are propagated; though for their Smallneſs they cannot be ſeen. But it is now Time to divert our Diſcourſe to another Subject: If your Curioſity leads to a farther Enquiry about theſe Matters, you may at your Leiſure conſult the Works of Dr. *Grew*, Monſ. *Malphigi*, *Lewenhock*, *Ray*, *Clerck*, &c. which will give you Satisfaction at large.

A. I am greatly obliged to you, *Sir*, for this conciſe and regular Epitome of the Science of Vegetation; and conſequently the true Theory of Plants: I never underſtood ſo much before, nor, indeed, have I Time to peruſe voluminous Authors.

CHAP. V.

Zoography, or the Philoſophy of Animals; of the humane Body, and its ſolid and fluid Parts; a Survey of the Nature of Beaſts, of Fowl, of Fiſh, of Inſects, of Reptiles, of Shell-Animals, &c. *of Health, Diſeaſe, Vigilance, Sleep, Dreams, Hunger, Thirſt, Death.*

A. PRAY what is the Etymology of the Word *Zoography?*

B. It is compoſed of the *Greek* Ζῶον, an *Animal*, or *Living Creature*, and Γραφὴ, a *Deſcription*; and thence it imports a phyſiological

ſiological *Deſcription* of the Nature and Properties of a *Living Creature*, which we call by the general Term *Animal.*

A. What are the general Diviſions of this Part of *Philoſophy?*

B. I ſhall here divide it with Reſpect to the different Perfection of *Animals*, viz.

1. *Anthropography*, concerning the humane Body.
2. *Zoography*, of the Bodies of Brutes in particular.
3. *Ornithography*, of the Nature of Birds or Fowl.
4. *Ichthyography*, of the Nature of Fiſh.
5. *Entomatography*, of the Nature of Inſects.
6. *Herpetography*, of the Nature of Reptiles.
7. *Zoophytography*, of the Nature of Shell-Animals.
8. *Symptomatography*, of the various Accidents common to animal Bodies.

A. Pray what do you particularly include under the firſt Diviſion, which you call *Anthropography?*

B. A brief phyſiological Deſcription of all the component Parts of the humane Body; which Parts are of two different Kinds, *viz.* *Solids*, and *Fluids*.

A. Which are the ſolid Parts of the humane Body?

B. Thoſe which follow: 1 Bones. 2. Cartilages. 3. Ligaments. 4. Muſcles. 5. Tendons. 6. Membranes. 7. Nerves. 8. Arteries. 9. Veins. 10. Ducts, or fine tubular Veſſels of various Sorts. Of theſe ſimple Solids thoſe more compounded Organs of Life do conſiſt.

A. Pray which are thoſe compound Organs of Life?

B. The Brain, and Cerebellum; the Lungs; the Heart; the Stomach; the Liver; the Spleen; the Pancreas; the Kidneys; the Glands; the Inteſtines; together with the Organs of Senſe, *viz.* the Eyes; the Ears; the Noſe; the Tongue.

A. Which are the fluid Parts of the humane Body?

B. They are theſe: 1. The Chyle. 2. Blood. 3. Saliva, or Spittle. 4. Bile. 5. Milk. 6. Lympha. 7. The Semen. 8. The pancreatick Juice. 9. Urine. 10. Phlegm. 11. Serum. And, 12. The aqueous Humour of the Eyes.

A. Pray what is a Bone, and how generated?

B. A Bone is a Bundle of hard Fibres, tied to one another by ſmall tranſverſe Fibres. In the *Fœtus* thoſe Fibres are porous, ſoft, and eaſily diſcerned; it is probable they are nouriſhed by the ſerous Part of the Blood. As their Pores fill up with a Subſtance of their own Nature, ſo they increaſe, harden, and grow cloſe; thus when the Pores are full of this Subſtance, the Bones are grown to their utmoſt Extent, Hardneſs and Solidity.

A. Are there not divers Sorts of Bones in the Body?

B. Yes; ſome are hollow, and filled with Marrow; others are ſolid clear through; ſome are very ſmall, others very large; ſome are round, and others flat; ſome are plane, others convex, or concave; where they are joined to each other, they make the various Joints throughout our Bodies.

A. Pray what is the Uſe of the Bones?

B. They are in us, as the Timber in the Building; the Uſe of which is to give Strength, Firmneſs, Solidity, Form and Beauty to the Whole.

A. Pray can you tell the Number of Bones in a humane Body?

B. Dr. *Keil* has reckoned 245; others make them to be 249, *viz.* In the Skull 14; in the Face and Throat 46; in the Trunk 67; in the Arms and Hands 62; in the Legs and Feet 60.

A. What doth a Bone yeild by a *chymical Analyſis*?

B. They produce much volatile Salt and Spirit, which are very ſubtle and penetrating; ſome Sulphur, very ſtinking; a little Phlegm, and much Earth.

A. What is that Part you call a Cartilage, I pray you?

B. A Cartilage, or Griſtle, is a ſmooth and ſolid Body, ſofter than a Bone; in it are no Cavities or Cells containing Marrow, nor is it covered with any Membrane to make it ſenſible as are the Bones. The Cartilages have a natural Reſort or Elaſticity, whereby they retrieve their natural Figure or Situation. They are chiefly in thoſe Places where a ſoft and eaſy Motion is required, as in the Ears, Noſe, Wind-pipe, *&c.* They cover alſo the Ends of all the Bones that are joined together for Motion.

A. Pray what are their Uſes?

B. They are appointed for the ſpecial Structure of ſome Parts, as the Ears, Noſe, *&c.* and for the eaſy Motion of the Bones in the Joints.

A. What, pray *Sir*, do yo call a Ligament?

B. A Ligament hath its Name from *Ligo*, to bind, and is a white ſolid Body, ſofter than a Cartilage, yet harder than a Membrane; they have no Cavities containing Marrow, nor any Senſe: Their chief Uſe is to bind and faſten the Bones (in their Articulation)

culation) together, leſt they ſhould be diſplaced by any violent Motion.

A. Pray what is a Muſcle?

B. A Muſcle is a Bundle of fleſhy, and often tendinous Fibres; of which all in the ſame Plane are parallel to one another, and are all incloſed by one proper Membrane. The fleſhy Fibres compoſe the Body (called the Belly) of the Muſcle; and the tendinous Fibres, the Extremities: Thus, in *Fig*. XLII, AB is the Belly of the Muſcle, C is its Head, and D its Tail, both tendinous.

A. How many Sorts of Muſcles are there?

B. Several: Some being long and round, as *Fig*. XLII; ſome plane and circular, as *Fig*. XLIII; ſome broad, whoſe Fibres lie ſpiral-wiſe, as *Fig*. XLIV; ſome broad, whoſe Fibres run ſtrait, as *Fig*. XLV; ſome whoſe Fibres lie divaricated, or converge from their Beginning to a narrow Tendon, as *Fig*. XLVI; ſome are double, which conſiſt of a Tendon running through its Body from Head to Tail, and a Row of Fibres on each Side, as *Fig*. XLVII; ſome are yet more double, having two or more tendinous Branches running through them with various Rows and Orders of Fibres, as *Fig*. XLVIII; ſome have only a ſmall long Body, which divides into ſeveral ſmall Tendons at the end, as *Fig*. XLIX; others alſo have two Bodies proceeding from one Head; and there are others yet of a different Sort from any here deſcribed.

A. Pray what is the Uſe of Muſcles?

B. They conſtitute the fleſhy Part of our Bodies, and give it that beautiful Form we obſerve over all its Surface. 2. But they principally ſerve for animal Motion; for by their Means all the Parts of the animal Body are moved.

A. Aye, indeed, pray how ſo?

B. Thus; each Muſcle, and every Fibre in a Muſcle, hath Nerves, Arteries and Veins, attending it; now by the Rarefaction of the Blood and Spirits in thoſe Veſſels, their Cavities are diſtended; the Muſcle muſt then ſwell of Courſe, and ſwelling, will contract and become ſhorter: Therefore the Bone, or Part, into which the Muſcle is inſerted, will by this Contraction of it, be drawn or pulled towards that Part where the Muſcle ariſes; and this is the general Theory of all animal Motion.

A. Pray what Number of Muſcles may there be in a humane Body?

B. Dr. *Keil* numerates 446 ſingle Muſcles in the whole Body; but others (leſs knowing) have reckoned different Numbers.

A. Pray what do you underſtand by a Tendon?

B. A Tendon is a Part conſiſting of nervous Fibres, devoid of any parenchymous or fleſhy Subſtance, inveſted in a Membrane common to all the Muſcles; and form what we call the Head C, and Tail D, of all Muſcles; or thoſe Parts by which they ariſe from, or are inſerted into the Bones of the ſeveral Limbs of the Body: The Number of Fibres in every Tendon is equal to that of the Fibres of the Muſcle, and are the ſame Fibres with them; they are thoſe white, hard, compacted Bodies, which we vulgarly call *Sinews*.

A. What Part is that you call a Membrane, pray?

B. A Membrane is a Web of ſeveral Sorts of Fibres, interwoven for the covering and wrapping up of ſome Parts; hence they are elaſtick, and of an exquiſite Senſe; here the innumerable Diviſions, Windings, ſerpentine Progreſſions, and frequent Inoſculations of Veins with Veins, and Arteries with Arteries, make a moſt agreeable Embroidery, and delicate Net-work, covering the whole Membrane.

A. Pray, *Sir*, what is the Uſe of Membranes?

B. To cover and wrap up the Parts; to ſtrengthen them; to ſave them from external Injuries; to preſerve the natural Heat; to join one Part to another; to cauſe an exquiſite Senſe; to ſeparate a Humour (by its Glands) for moiſtening the Parts, *&c.*

A. Are there not divers Kinds of Membranes?

B. Yes; as the Scarf-skin, covering the whole Body; the Skin of the Body it ſelf; the Meninges of the Brain; the Pleura in the Breaſt; the Pericardium involving the Heart; the Perioſteum inveſting the Bones; the Tunicles, or Coats of the Veſſels, as the Stomach, Bladder, Veins, Arteries, Inteſtines, Teſticles, *&c.* are all Membranes of different Kinds.

A. Pray what do you call a Nerve?

B. A Nerve is a long and ſmall Bundle of very fine Pipes, or hollow Fibres, wraped up in the Membranes of the Brain, from whence they have their Beginning.

A. What do you find to be the Uſe of the Nerves?

B. It is very probably ſuppoſed, they are the immediate Organs of all Senſation; for to every external Organ of Senſe, as the Eye, the Ear, the Noſe, the Tongue, are detached one or more Pair of thoſe Nerves from the Brain; alſo thoſe Nerves, which proceed from the ſpinal Marrow, are ſpread through all Parts of the Muſcles and their Membranes, and to every Point in the Superficies of the Body; and thereby make the whole ſenſible.

A. Pray by what Means do the Nerves render the Parts ſenſible?

B. It is imagined, by the Motion of an exceeding fine and inviſible Fluid they contain, called the *animal Spirits*; by which Impreſſions are communicated to the Mind (whoſe Seat is in the Brain) from all Parts of the *animal Body.*

A. How many, or what Quantity of Nerves may there be in the Body?

B. There be ten Pair, which proceed from the medullary Subſtance of the Brain, which are chiefly diſtributed to all the Parts of the Head and Neck; from the ſpinal Marrow there proceed through the Vertebræ, thirty Pair to all the other Parts of the Body; and thus in all there are forty Pair; for they come forth originally by Pairs.

A. Pray what do you call Arteries?

B. They are thoſe Pipes, Tubes, or Channels, which convey the Blood from the Heart to all Parts of the Body.

A. Pray what is their Compoſition or Texture?

B. They conſiſt, or are compoſed of three Coats, *viz.* 1. The *firſt* ſeems to be a Web of fine Blood Veſſels and Nerves, for nouriſhing the Coats of the Artery. 2. The *ſecond* is made up of circular, or rather

ther ſpiral Fibres; of which there are more or fewer Lays, according to the Bigneſs of the Artery. 3. The *third* and inmoſt Coat is a fine, denſe, tranſparent Membrane, which keeps the Blood within its Channels; the Arteries branch out into various Ramifications, and become inviſibly ſmall at laſt.

A. Pray whence is that Pulſation we find in ſeveral Parts of our Bodies?

B. This is a Motion of the Arteries only; the Blood being ejected from the left Ventricle of the Heart into the great Artery, ſome and ſome at a Time, preſſeth the Sides of the Artery, and cauſes an intermitting Dilatation thereof; which is continued by the conſtant pulſive Motion of the Blood, and the Spring or Elaſticity of the Artery, acting on it; hence therefore enſues a conſtant alternate Dilatation and Contraction of the Coats of an Artery; and is what we properly call the *Pulſe.*

A. Pray what is the Difference between Arteries and Veins?

B. Veins are only a Continuation of the capillary Arteries at their Extremities, and convey the refluent Blood back again to the Heart; in their Return they unite their Channels as they approach the Heart, and form at laſt the three large Trunks, *viz.* the *Vena Cava Aſcendens*, *Deſcendens*, and the *Vena Porta*, as they are called.

A. And, pray, how happens it that Veins have no Pulſe?

B. Becauſe the Blood is poured into them at the *Anaſtomaſis* in one continued even Stream; and becauſe it moves from a narrower Channel to a wider; the Preſſure of the Blood againſt the Sides of the Veins being leſs than that againſt the Sides of the Arteries.

A. Pray what do you call thoſe Ducts or tubular Veſſels, you mentioned under the laſt Head of ſolid Parts?

B. Thoſe ſmall, fine, hollow Pipes or Tubes diſperſed through all Parts of the Body; which convey, ſome a Lymph, called *Lymphæducts*; others a milky Liquor, called *lacteal Veins*; and others, convey other Juices and Humours of the Body to their proper Places.

A. Having thus heard you on the Nature and Uſe of the more ſimple Solids; I ſhall be obliged to you for a ſmall Account of the more compound ſolid Parts, which you call the great *Organs of Life*: And, pray, what is the Nature of the Brain.

B. The whole Subſtance of the Brain is divided into two Parts; that which lies in the Fore-part of the Skull, called the *Cerebrum*; and that lying in the Back-part, called the *Cerebellum*. In the Cerebrum, or Fore-part of the Brain, there are obſerved two Kinds of Subſtances, the external and internal; the external Subſtance is ſoft, glandulous, and of the Colour of Aſhes; this Part receives the capillary Branches of the Veins and Arteries belonging to the Brain, and ſendeth from its little oval Glands an infinite Number of Fibres, which all together make up the medullary Subſtance of the internal Part of the Brain and Cerebellum, which going out of the Skull, form the Nerves and ſpinal Marrow.

A. Pray what is the Uſe of the Brain?

B. The Uſe of the Brain is to ſeparate from the Blood brought thither, the fineſt and ſubtleſt Parts thereof, called *animal Spirits*, by the Glands in the external Part, which are received from thoſe Glands by the Fibres of the medullary Subſtance, and are from thence convey'd by the Nerves (which theſe Fibres compoſe) to all Part sof the Body; giving the Faculty of Senſation to the whole.

A. Pray what is the Nature of the Lungs?

B. The Subſtance of the Lungs is compoſed of an infinite Number of little Lobes or Spheres, of various Figures and Magnitudes, whoſe Surfaces are ſo adapted as to leave but few and ſmall Interſtices; theſe ſmall Lobes are diſpoſed like ſo many Bunches of Grapes on the Sides of the Branches of the Wind-pipe: Each little

Lobe contains within its own proper Membrane, an infinite Number of ſmall and round Bladders, which leave ſmall Interſtices between full of ſmall Membranes, like thoſe which bind the Lobes together; The Extremities of the Branches of the Wind-pipe open into the Cavities of theſe ſmall Bladders, which are probably formed by its Membranes; but the fine Blood Veſſels are only ſpread upon the Bladders like a Net, with frequent and large Inoſculations.

A. Pray what is the Uſe of the Lungs?

B. This is the great Organ of Breathing or Reſpiration; as the Air by its Weight forceth into every Cavity, ſo as ſoon as the Fœtus is born it ruſhes into the Cavity of the Lungs, and fills the little Veſicles, and by extending them compreſſes the ſmall Blood Globules in the Veſſels ſpread upon them; this Compreſſion is much greateſt when the Air is expelled out of the Lungs by the Contraction of the Breaſt; and by this Compreſſion, the red Globules of Blood, which through their languid Motion in the Veins, were grown too big to circulate, are again broken and divided in the Serum, and ſo the Blood is anew made fit for Nutrition and Secretion. Dr. *Keil* alſo thinks that the Air doth hereby enter and mix with the Blood. Dr. *Cheyne* ſaith, the elaſtick Globules of the Blood are hereby formed. And others hold other Opinions of the Uſes of Reſpiration. But I think it ſtrange, that *Etmuller*, amongſt his 14 Uſes thereof, has not mentioned the vital Spirit of the Air, which probably is thereby intermixed with the Blood, and diffuſed through all the Body, and is therein the Principle of animal Life; ſince it is well known Animals cannot live in Air deprived of this Spirit. Neither has Mr. *Derham* hinted hereat.

A. Pray what is the Nature and Compoſition of the Heart?

B. The Heart (ſaith *Boerhave*) and its Auricles are real Muſcles, and act with a muſcular Power; for all the Fibres gradually growing ſhorter diminiſh the Length of the Heart and increaſe its Breadth; they accurately ſtreighten the Cavities of the Ventricles; dilate the tendinous Mouths of the Arteries; determine the Valves of the Mouths of the Veins for the Stoppage of their Contents; and drive, with great Force, its contained Blood into the dilated Mouths of Arteries; in order to its Circulation through the Body.

A. Pray what is the principal Service of the Heart to the humane Body?

B. This wonderful Muſcle has two Motions, which they call *Syſtole*, and *Diaſtole*; the *Syſtole* is when the Fibres contract and ſtreighten the Cavities; the *Diaſtole* is when this Muſcle ceaſeth to act; its Fibres return to their natural Site, and its Cavities become large and wide. Now the *Vena Cava* returning to the Heart, the exhauſted ſuperfluous Blood, with the Chyle newly mixed herewith, pours it through the right Auricle, whence it is detruded into the right Ventricle or Cavity of the Heart; by its *Syſtole* it is thence driven into the pulmonary Artery, which conveys it to, and diſtributes it through all the Parts of the Lungs; the Blood being here by Reſpiration, prepared, reduced, mixed and impregnate with the vital Spirit, and nutricious Principles of the Air, is remanded back again by the pulmonary Vein to the left Auricle; thence into the left Ventricle of the Heart, which is then in its *Diaſtole*; *laſtly*, in the *Syſtole* of this Ventricle, the Blood now refected is thruſt into the great Artery, called the *Aorta*, which carries it again through all the Body: Thus the Heart is the inſtrumental Cauſe of the Blood's Circulation.

A. In the next Place, pleaſe to give me ſome Account of the Nature of the Stomach.

B. The Stomach is compoſed of four Membranes: The *firſt* and *inmoſt* is a large muſcular Coat, lying in Plaits, and containing a great Number of Glands, thence called the *Tunica Glanduloſa*, The *ſecond* Coat is much finer and thinner; is altogether nervous, and therefore of exquiſite

Senſe. The *third* Tunicle is made of ſtrait and circular Fibres ; ſo that by this muſcular Coat the Ends of the Stomach are drawn towards its Middle, and the whole is equally contracted. The *fourth* is the common external Cover of the whole Stomach; it proceeds from the *Peritonæum.*

A. Pray to what Uſe doth the Stomach ſerve ?

B. The Uſe of the Stomach is Digeſtion; which is the Diſſolution or Separation of the Aliments or Food into ſuch minute Parts as are fit to enter our lacteal Veſſels, and circulate with the Maſs of Blood : This is principally effected by the Saliva or Spittle of the Mouth ; the fermenting Juice in the Stomach, ſeparated by its aforeſaid Glands ; by the Liquors we drink ; and, *laſtly*, by the continual Motion of the muſcular Coats of the Stomach, whoſe abſolute Power is, by *Pitcairne*, demonſtrated to be equal to 117088 Pound Weight ; to which, if the abſolute Force of the Diaphragm and Muſcles of the Abdomen be added, the Sum will amount to 250734 Pound Weight, which is above 2238½ hundred Weight, or near 112 Tun ; No wonder then the very hardeſt Diet, or Bones themſelves, ſhould ſo ſoon be reduced to a liquid Subſtance, we call the *Chyle*, by ſuch prodigious conſpiring Forces !

A. Pray, *Sir*, what do you make of the Liver?

B. The common Membrane being raiſed, its Subſtance ſeems to be compoſed of ſmall Glands of a conick Figure, and bound together by a proper Membrane into ſeveral Heaps or Lobes, which, like Bunches of Grapes, hang to the Branches of the Veſſels (*viz.* the *Vena Portæ*, and the *Vena Cava*) from which each ſmall Gland receives a Twig, and the Lobes are tied to one another by fine Membranes, which fill up the Spaces between them; and thus the parenchymous Subſtance of the Liver is formed.

A. And, pray, what is its Uſe?

B. The *Vena Portæ* brings the Blood to the Liver full of Bile, for its Secretion by the Glands of the Liver; and the *Vena Cava* carries back the Blood which remains, to the Heart. The Bile thus ſtrained from the Blood is, by ſmall Veſſels, brought to the Gall-bladder, one Part; and the other Part is ſeparated immediately into the Duct, called the *Porus Bilarius*; this Duct going out of the Liver, joins the Neck of the Gall-bladder at ſome Diſtance, and forms one common Duct, called the *Choledochus*, through which both Sorts of Bile mix and paſs to the Lower-end of the duodenum Gut, whereinto it flows in order to mix with the Chyle: Thus the Uſe of the Liver is to ſeparate the Bile from the Blood.

A. Pray what is the Nature and Make of the Spleen?

B. The Subſtance of the Spleen (contained within two Membranes) is compoſed of an infinity of Membranes, which form little Cells and Cavities of different Size and Figure, which communicate with one another, and are always full of Blood.

A. Be pleaſed, *Sir*, to tell me the Uſe thereof.

B. The Ancients knew nothing of its Uſe; nor can the Moderns do more than conjecture at it. You may ſee Dr. *Keil*'s ingenious Hypotheſis of its being Nature's Store-houſe, in which ſhe depoſites the arterial Blood for the Uſe of the Liver, in his *Anatomy*; and the learned Diſquiſitions of the great *Boerhave* on this Subject, in his *Inſtitutions*, pag. 139.

A. Pray what is that you call the Pancreas?

B. It is the ſame as is vulgarly called the *Sweet-bread*; it is called *Pancreas* from ϖαν, *all*; and Κϱεας, *Fleſh*; as much as to ſay, *a Part all Fleſh*: It is compoſed of an infinite Number of little Glands, it ſelf being only a large Gland of the conglomerate Kind; whence its Subſtance, as we find, is always ſoft and ſupple.

A. Pray what is its Uſe?

B. To ſecern from the Blood brought thither a Liquor called the *pancreatick*

Juice, which is conveyed by a proper Duct to the duodenum Gut, there to dilute the Chyle.

A. Pray what is the Subſtance of the Kidneys?

B. The Kidneys are likewiſe two large Glands, whoſe parenchymous Subſtance is compoſed of an Infinity of very ſmall Glands, every where interwoven in the Net-like Inoſculations of the fine capillary Branches of their Arteries and Veins: From each ſmall Gland proceeds a long ſmall Tube; theſe Tubes approaching towards the Cavity of the Reins, gather together in little Bundles, and form the inner Subſtance of each Kidney.

A. And, pray, is not their Uſe to ſeparate the Urine from the Blood?

B. Yes; the Blood being conveyed to them by the emulgent Arteries, hath its ſerous briny Part ſtrained off by their little Glands, and then is returned again by the emulgent Veins; the Urine thus ſeparated, runs down by the Ureters into the Bladder.

A. Pray what is the Nature and Texture of the Glands?

B. The Moderns have reduced all the Glands of the Body to two Sorts, *viz.* *Conglobate Glands*, and *Conglomerate Glands.* A *Conglobate Gland* is a little ſmooth Body wrapped up in a fine Skin, by which it is ſeparated from all other Parts, only admitting an Artery to paſs in, and a Vein and excretory Canal, to come out: Of this Nature and Sort, are the Glands of the Brain, of the Lips, and of the Teſticles. A *Conglomerate Gland* is compoſed of many little *Conglobate Glands*, all tied together and wrapped up in one common Tunicle or Membrane, whoſe various excretory Ducts uniting, form one or more larger Pipes, or evacuating Veſſels: Of this Sort are the *Breaſts*, the *Sweet-bread*, the *Kidneys*, &c.

A. Their Uſe I underſtand is ſecretion of Humours from the Blood.

B. It is ſo: Thus, the Glands of the Brain ſecern the Animal Spirits; thoſe of the Mouth, the Saliva, or Spittle; thoſe of the Breaſts, Milk; thoſe of the Reins, Urine; thoſe of the Liver, Bile; thoſe of the Teſticles, the generative Semen; and thoſe of the Skin, the inſenſible Matter of Perſpiration, or Sweat. The Number of theſe ſmall cuticular Glands is ſomewhat wonderful, it is ſuppoſed, that one Grain of Sand will cover no leſs than 125000 of them; if then we reckon only 2600 of theſe Grains to an Inch Square, and allow at a Medium the Surface of a Man's Body to be equal to 14 ſquare Feet; then there will be of thoſe ſmall Glands in the Skin, the Number 32400000000; each of which contains tain a Pore, or inviſible Spiracle, through which we conſtantly perſpire.

A. Pray what Quantity of Matter goes off by this inſenſible Perſpiration?

B. *Sanctorius* tells us, in his *Aphoriſms*, that by weighing himſelf he has found, 1. That a Man ſleeping perſpires twice as much as when awake. 2. That a ſound Man in one Night of ſeven Hours Sleep, generally perſpires 50 Ounces, or 3 Pounds *Averdupoiſe*; or 4 Pounds *Troy* Weight. 3. That ſcarce half a Pound of this perſpires in the firſt 5 Hours. And we cannot wonder hereat, ſince it appears there are above three hundred thouſand Millions of Pores in the Body of a middle ſized Man; through which there muſt of Neceſſity go off a much greater Quantity than either by Stool or Urine, or both together.

A. Well, I am wonderfully pleaſed to know this ſurprizing Part of Philoſophy, and do intend for the Sake hereof to buy *Sanctorius*'s Book: But, to go on, pray what is the Nature and Uſe of the Inteſtines?

B. The Inteſtines are a long and large Pipe, which by ſeveral Circumvolutions and Turnings, reaches from the Pylorus of the Stomach to the Anus: They are knit all along to the Edge of a Membrane, called the Meſentery, and are 6 Times as long as the Body to which they pertain: Their Uſe is by a peculiar vermicular Motion of their ſpiral-fibred Coats, to convey along, and extrude out of the Body, the *Fæces*; or the recrementitious Part of the Food, after the Chyle is ſtrained from it.

A. Pray how many different Organs of Senſation are there?

B. Four particular Ones, *viz.* the Eye, for ſeeing; the Ear, for hearing; the Noſe, for ſmelling; and the Tongue for taſting: And there is one general Senſe, *viz.* of feeling, common to all the Parts of the Body.

A. Pray what is the Structure and Uſe of the Eye?

B. This curious and moſt wonderful Piece of all Nautre's Works, is admirably contrived with various Coats, Muſcles, Veſſels, and Humours of 3 ſeveral Kinds, for the Purpoſe of Viſion: The firſt Humour of the Eye is called the *aqueous Humour*, being in all Reſpects like Water, but of a ſpirituous Nature; for it will not freeze in the greateſt Cold. The ſecond is called the *chryſtalline Humour*, being tranſparent, and more ſolid than either of the other; its Figure reſembles an optick Lens, convex on both Sides, and its Uſe in the Eye is the ſame. Behind this lies the vitreous or glaſſy Humour, it is very much like the White of an Egg, is in greater Abundance than either

ther of the other, it gives the Eye its ſpherical Form; and is thicker than the *aqueous*, but thinner than the *chryſtalline Humour.* Next this Humour, on the Bottom of the Eye, is ſpread a fine curious Membrane, called the *Retina*, through which are expanded the medullary Fibres of the optick Nerves, which come from the Brain. Now the Rays of Light, which come from all Parts of any Object, falling upon the *aqueous Humour* of the Eye, are through it refracted to the *chryſtalline Humour*, by which as a double convex Lens (kept always at a proper Diſtance by the *glaſſy Humour*) they are all converged and united on the *Retina*; the Impreſſion thereof, being communicated to the common Senſory of the Brain by the optick Nerves, doth there preſent to the Mind the Species and Image of the Object; and thus is Viſion performed by Means of the Eye.

A. Pray how is the Senſe of Hearing performed by the Ear?

B. I have already told you, that Sounds are brought to the Ear from the ſonorous Body by Means of the Air; and the external Part of the Ear is ſo contrived by its Ridges and Hollow, that Sounds, being gathered into the Ear as into a Tunnel, are thereby directed to the *Meatus Auditorius*, through which they paſs and ſtrike upon a thin tranſparent Membrane of an oval

Figure, ſet a little obliquely acroſs the Paſſage of the Ear; behind this Membrane there is a pretty large Cavity, which with the ſaid Membrane, from its Reſemblance, is called the *Tympanum*, or *Drum of the Ear*: In this Cavity are four ſmall Bones, which from their Form are called *Melleolus*, or the *Hammer*; the *Incus*, or the *Anvil*; the *Stapes*, or *Stirop*; and the *Os Orbiculare*, or circular Bone. Within the *Tympany* there are ſeveral other Cavities, as the *Veſtibulum*, the *Labyrinth*, and the *Cochlea*; theſe internal Cavities are always full of Air; wherefore the Sounds in the external Air ſtriking on the Drum, move the four little Bones in the *Tympany*, and theſe in like Manner move the internal Air, which maketh an Impreſſion on the fine Branches of the auditory Nerve ſpread through the *Veſtibulum*, the winding Tubes of the *Labyrinth*, and *Cochlea*; and thus all Refractions and Modulations of the external Air become perceptible, and conſequently all the different Sounds they convey become audible, and intelligible to the Mind, by the Communication of theſe Nerves with the Brain, or common Senſory.

A. Pray how is the Senſe of Smelling effected in the Noſe?

B. The Cavity of the Noſe is divided into two Parts, we call the *Noſtrils*, by a

Partition, of which the upper Part is bony, and the lower, cartilaginous: The upper Part of the Cavity is covered with a thick glandulous Membrane, above which, the olfactory Nerve is finely branched out and ſpread over the Membrane of the ſpongy Bones of the Noſe, and the other ſinuous Cavities of the *Noſtrils*: Whence the Exhalations of Odours entring the *Noſtrils* make their Impreſſions on the Fibres of the Nerves, which by their Communication with the Brain, excite in the Mind the Smell or Senſation of Odours of every Kind.

A. And thus, I ſuppoſe, you account for the Senſe of Taſte in the Tongue.

B. The Tongue is covered with two Membranes; the external is thick and rugged, eſpecially in Beaſts; the internal Membrane is thin and ſoft; upon it appear ſeveral Papillæ, or ſmall Riſings, like the Tops of the ſmall Horns of Snails; theſe Papillæ are made of the Extremities of the Nerves of the Tongue, and piercing the external Membrane, are conſtantly affected by thoſe Qualities in Bodies, which are their Taſtes excited in the Mind by means of theſe nervous Papillæ; and thus are theſe Papillæ the immediate Organ of Taſting.

A. Pray how is the general Senſe of Feeling performed?

B. Of this a general Account muſt ſerve: I have already told you that from the Brain and ſpinal Marrow, there iſſue out divers Pairs of Nerves, which are ramified and diſperſed through all Parts of the Body; and conſequently no Impreſſion on any Point, either on the Superficies, or internal Compages of the Body, can be any how made, but it muſt immediately affect either the Extremity, or ſome Part of a Nerve, and is therefore immediately communicated to the Brain by the animal Spirits; and thus the Mind becomes conſcious of every Motion, Affection, or Accident of the Body; and this we call the *Senſation of Feeling.*

A. Having thus obliged me with an Account of the ſolid Parts, and of the Organs and Manner of Senſation, I beg you would now proceed to deſcribe the Fluids of the humane Body; and firſt, pray, what do you call the *Chyle?*

B. This is a white milk-like liquid Subſtance, into which the Food is converted by the Concoction and Digeſtion of the Stomach, as before I told you; the *Chyle* paſſing by the *Pylorus* out of the Stomach into the firſt of the Inteſtines, called the *Duodenum,* in it, and in the next, called the *Jejunum,* it mixeth with the Bile and pancreatick Juice; by which Means the *Chyle* undergoes a farther Preparation; the more alimentary Part being hereby refined and ſeparated, is received into the numerous Orifices of the firſt lacteal Veins, opening into the ſaid Inteſtines; by theſe it is conveyed to, and ſtrained through the Glands of the Meſentery; whence it is received by a ſecond Sort of lacteal Veins, and carried to the Baſon, called the *receptaculum Chyli*; where being duly impregnated with the Lymph, from the Lymphæducts there poured into it, it is thence carried upward by the thorack Duct, and emptied into the left ſubclavian Vein, where it is mixed with the refluent venal Blood, deſcends into the right Ventricle of the Heart, is thence circulated through the Lungs into the left Ventricle, and from thence through all the Parts of the Body: And this is the animal Oeconomy, or ordinary Method by which the Blood is renewed, and Life continued.

A. Pray what is the Blood?

B. It is a vital Stream proceeding from the Fountain of the Heart, and circulating conſtantly through the whole Body by the Canals of the Arteries and Veins. *Boerhave* ſaith, if it be viewed with a *Microſcope*, it appears to conſiſt of ſmall red Globules ſwimming in a thin tranſparent Serum, and that each Globule is made up of ſix leſſer ones, which reſolved, take upon them the Nature of the Serum, whoſe Colours are various. He farther ſaith, that the Mixture, Fluidity, Heat, and Redneſs of the Blood is owing to, and preſerved by the circulatory Motion thereof.

A. Pray what is the Rate of the Blood's Motion through the Body?

B. Each Ventricle of the Heart will contain about an Ounce of Blood; the Heart contracts about 4000 in an Hour; hence there paſſeth through the Heart every Hour 4000 Ounces of Blood, which is 250 *l.* Weight. Now an Ounce of Blood is equal in Bulk to 1.659 Inches; and if we ſuppoſe the Heart contracts 80 Times in a Minute, then 80 Ounces of Blood will be equal to 132.72 Inches, which paſſeth the Heart in one Minute. Now Dr. *Keil* found the Diameter of the *Aorta* to be 0.73 Parts of an Inch, and thence its Orifice 0.4187; by which divide 132.72, and the Quotient will be the Length of the Cylinder, or Space through which the Blood will move in a Minute, *viz.* 316 Inches, or 26 Feet. But, becauſe of the Diaſtole of the Heart, which takes up half the Time of a Pulſation, there goes out of the Heart 80 Ounces in ½ a Minute; whence the Blood's Velocity will be double, or it moves at the Rate of 52 Feet in a Minute.

A. And, pray, is the Velocity through the Trunk, the ſame as through all the Branches taken together?

B. No; for the ſame ingenious *Anatomiſt* found the exact Proportion of the Branches to the Trunk of the Artery to be as 12387 to 10000, and conſequently the greateſt Velocity of the Blood will be to the leaſt, as 5233 to 1; or the Blood moves 5233 Times ſlower in ſome capillary Arteries, than it does in the *Aorta*. The Blood is received from the Arteries into the Veins, where it ſtill moves ſlower as it approaches the Heart. Now the Arteries are to the Veins, as 324 to 441; and therefore the Blood moves in the Veins above 7116 Times ſlower than in the *Aorta*.

A. What Quantity of Blood do you find to be in the *humane Body*?

B. You ask a Queſtion very difficult to be anſwered: At preſent I cannot find any Perſon can certainly tell: *Authors* determine from 10 to 25 *lb*. and Dr. *Keil* reckons the whole Body conſiſts of near $\frac{2}{3}$ Fluids, the greateſt Part of which is Blood.

A. What do the *Chymiſts* find the Blood to conſiſt of?

B. Of much *volatile Salt*, and *Spirits*; ſome *Phlegm* and *Sulphur*; a little *Earth*; and but little or no *fixed Salts*: *Alcalies* diſſolve in it, and *Acids* coagulate it.

A. How are the other *Fluids of the Body* produced?

B. They are all ſeparated from the Blood in ſome Part of the Body or other by the

Glands: Thus the *Saliva* or *Spittle*, is ſecerned by parodital Glands behind the Ears, and maxillary Glands of the Mouth; the *Bile* is ſeparated by the Liver; the *Milk* is ſtrained off from the Blood by the Glands of the Breaſts; the *Lymph* is a fermenting Liquid ſecerned by the ſmall conglobate Glands in ſeveral Parts; the *Semen* is ſecreted from the Blood by the Teſticles, brought thither through various Circumvolutions and Contortions of the *ſpermatick Arteries*; the *Pancreas*, or *Sweet-bread*, alſo ſeparates a ſweet lympid Liquor or Juice, to dilute and refine the *Chyle*; the *Urine* is ſecerned by the Reins; it contains *volatile Salt*, *Spirit*, an *oily Sulphur*, *Phlegm*, and *Earth*; from *Urine* fermented is diſtilled that luminous Matter called *Phoſphorus*, which is either ſolid or liquid; *Phlegm* is a mucous viſcid Matter, ſeparated by the Glands of the Mouth, Noſe, &c. *Serum* is the aqueous Part of the Blood, which is not diſcerned from the Blood it ſelf in the Body; but taken out, it ſeparates from the coagulated Blood, by the Action of the Cold; the *aqueous Humour* of the Eye, ſecerned from the *arterial Blood* in the Veſſels of the Eye; the *chryſtalline* and *vitreous Humours* are improperly ſo called, they conſiſting of an infinite Number of ſmall Veſſels repleat with circulating *Fluids*.

A. Sir, I am under an infinite Obligation to you for taking ſo much Pains for my Information; yet, as you ſeem to do it with a great deal of Pleaſure, I ſhall be bold to ask a few Queſtions more; and, pray, what do you ſay of the *Nature of Hair*?

B. When we examine the *Hairs* with a *Microſcope* (ſaith Dr. *Keil*) we find they have each a round bulbous Root lying pretty deep in the Skin, and which draw their Nouriſhment from the ſurrounding Humours; that each Hair conſiſts of 5 or 6 others wrapped up in a common Tegument or Tube: They grow as the Nails do, each Part near the Root thruſting forwards that which is immediately above it; and not by any Liquor running along the Hair in Tubes, as Plants grow. Their different Colours depend on the different Quality and Temperament of the Humours producing them; they ſerve for the Covering and Ornament of the Body. Mr. *Derham* gives us the Repreſentation of two Hairs of a Mouſe (the moſt tranſparent of any) the one in *Fig*. L. where *a* is its Appearance through a ſmall Magnifier; and A as it appears through a large one. *Fig*. LI. *c* and D are the ſame Views of another Hair, to ſhew the different internal Make of the Hair of the ſame Animal.

A. Pray what are the *Nails*?

B. Our *Nails* are of the ſame Nature as the *Hoofs of Beaſts*; and are nothing but the Covers or Sheaths of *Papillæ Pyramidales* of the Skin on the Extremities of the Fingers and Toes, which dry, harden, and lie cloſe upon one another.

A. You have been long telling what thoſe Parts are of which our Bodies conſiſt; but, pray, how are our Bodies at firſt generated or formed in the *Womb*? This you have not yet told me.

B. The Learned of late have found by their *Microſcopes*, that not only Man, but all Animals, do really exiſt (in their proper Form compleat in all their Parts) in the Seed of the Male Animal, before Generation, in a ſmall inviſible State, called *Miniature*. It is amazing to ſee the prodigious Number of little Creatures, like ſo many Tadpoles, ſwimming every Way in the Male Sperm of all Animals; nor is it leſs curious to obſerve their languid Motion in ſuch as are *poxed*; and how they ſenſibly recover their former Briskneſs as the Diſtemper abates. *Leeuwenhoeck* tells us of one whoſe Wife for ſome Years did not conceive, becauſe there were none of theſe *Animalcules* to be found in his Seed; thoſe Animals are ſo ſmall that 3000000000; *i. e.* three thouſand Millions of them are not equal to a Grain of Sand, whoſe Diameter is but the 100th Part of an Inch.

The *Animalcule* that has the good Luck to get ſafe into the *Womb*, through the *fallopian Tubes* in a Kind of Egg, is there foſtered a while ſome how, 'till at length, the *Placenta* appears like a little Cloud on one Side of the external Coat of the Egg; and at the ſame Time the Spine of the Embryo is grown ſo big as to be viſible, and a little after, the *Brain* and *Cerebellum* appear like two ſmall Bladders, and the Eyes next ſtand gogling out of the Head; then the *Beating of the Heart*, or *Punctum Saliens*, is plainly to be ſeen, and the Extremities of the Body diſcover themſelves laſt of all; ſo far Dr. *Keil:* And this is the preſent *Theory of Generation*; and the ſame both in *Plants and Animals.*

A. Pray what do you obſerve in particular of the *Nature of Beaſts?*

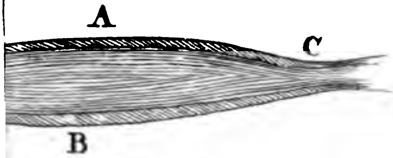
B. The Nature of Beaſts, or Quadrupeds, is, with Reſpect to the ſenſitive Life, or animal Oeconomy, the ſame with that of Man already deſcribed: What I ſhall here take Notice of then, ſhall be thoſe Particulars wherein the Brute differs from a Man, and is what he is; the Chief of which are the following, 1. Their external Form and Shape, which is almoſt infinite; and is that which chiefly diſtinguiſhes the various Species of Brutes. 2. Their Size, of which there are numerous Degrees; the greateſt of all are the *Elephant*, and *Rhinoceros.*

verns. 3. Their prone Poſture, neceſſary to their Way of Living. 4. Their Motion, or Gait, which is on 4 Legs, and are therefore called *Quadrupedes.* 5. The ſpecial Contrivance and Form of their Heads, which is infinitely various. 6. They are ſome of them endued with Horns of various Figures and Sizes. 7. They have a ſpecial Form and Structure of their Ears externally. 8. The Make of the Eye is very different in different Species of Animals. 9. The Neck is adapted to the Length of their Legs, except only in the Elephant, which hath his Proboſcis or Trunk to ſupply that Defect. 10. The Form of their Legs is peculiar, yet different in divers Species; whence the ſlow Motion of ſome, and wonderful Agility and Swiftneſs in others. 11. They are all provided with Tails of different Length, Size, &c. whoſe Uſe is to defend themſelves from the Moleſtation of Flies, &c. 12. Their Bodies are clothed with various Teguments of Hair, Wooll, Spines, Down, &c. ſuitable to their particular Occaſions of Life. 13. Their Feet are, ſome cloven into Hoofs, others divided into Claws, with variety of different Nails to anſwer their various Purpoſes of Life. 14. Their Noſtrils are ſomewhat differently formed from ours, and from one anothers. 15. Their Brain is conſiderably leſs in Proportion to their Bodies,

dies, than Man's. 16. They have ſome of them a peculiar Membrane, called the *nictitating Membrane* of the Eye, by which the Eye, frequently winking and contracting the Pupil, is preſerved from the Annoyance of the Graſs, Stubble, *&c.* in gathering their Meat. 17. They are provided with a ſtrong, tendinous, and inſenſible Ligament, braced from the Head to the Middle of the Back, called the *white Leather*, which ſuſpends the weighty Head without Pain, in Grazing, *&c.* 18. The Stomachs of Brutes are different from ours, and from each others, both in Size and Number; for ſome have ſmall, others large Stomachs; in ſome, one only; in others, two or more; thus the *Dromedary* hath four Stomachs. 19. Some have the wonderful Faculty of Rumination, or chewing the Cud; for the compleat Maſtication of the Food at the reſting, leiſure Times of the Animal. 20. The Hearts of Animals are of ſpecial Structure, in ſome it hath but one Ventricle, as *Frogs*; in others two; and in ſome three Ventricles, as in the *Sea-Calf*, &c. 21. Some Animals live only on Land, others, called *Amphibious*, live both on Land and in the Water. 22. The Food of Brutes is very various, ſome feeding on Fleſh, called *Carnivorous*; others on Graſs, called *Graminivorous*; ſome on Grain and Seeds, called *Granivorous*, &c. Beſides innumerable other Differences that might be named, of leſs note, between a *Man* and a *Brute.*

A. Pleaſe now to oblige me with a ſhort Account of the *Nature of Fowls.*

B. The *Philoſophy of Fowl*, or the *feathered Tribe*, is really wonderful, as will appear from a ſhort Survey thereof: For, 1. With Reſpect to their Generation, they are produced from Eggs, and are therefore called *oviparous Animals.* 2. Their Motion is two-fold, *viz.* flying and walking: And are thereby rendered, 3. The Inhabitants both of the Land and Air: For which Purpoſe, 4. They are wondrouſly contrived with a Pair of Wings to buoy themſelves up in the fluid elaſtic Sphere of Air, and whereby they keep their Bodies on a due Ballance and Equipoiſe in their Motion. 5. The Tails of Birds are given them to ſteer their Courſe, keep them ſteady in Flight, and to aſſiſt them in their Deſcents and Aſcents into the Air. 6. The Plumage of Birds is a wonderful Thing, their Feathers cloath and beautify them; a Feather is an amazing Production in every Part, the *Quill*, the *Rib*, and the *Vanes*, being thoroughly underſtood: The Pith in the *Rib* appears through a *Microſcope* (on the tranſverſe Section *a*) as is repreſented in A, *Fig.* LII. And a *Vane* of a *Feather* (as *b*) appears like another *Feather* when magnified, as in B, *Fig.* LIII. where you obſerve the net-like Texture of its membranous Part, and C is the little End magnified. 7. The Feet of Fowl are very particular, being ſpread ſome with Membranes for ſwimming, as *Ducks*, *Geeſe*, &c. ſome without for ſteady walking, perching, holding their Prey, *&c.* 8. The terrible ſharp pointed Talons in Birds of Prey are very remarkable, as thoſe of the *Eagle*, *Vulture*, &c. 9. The Heads of Birds are admirably ſuited for making Way through the Air, being very near the Figure of Sir *Iſaac Newton*'s Solid of leaſt Reſiſtance. 10. The *Beak*, or *Bill*, is a ſtrange Piece of Art, their very Jaw-bones, as it were, growing out of their Head and meeting in a Point, wonderfully adapted to pierce the Air, gather Food, and penetrate Wood, Earth, *&c.* for Prey. 11. Their Ears ſtand not out from the Head to hinder Flight. And, 12. The commodious Situation of the Eyes of Birds is ſurpriſing; for each of their Eyes takes in very near an *Hemiſphere*, and conſequently with both Eyes they can ſee nearly all around them at once, and ſo the better ſeek their Food and eſcape Dangers. 13. The wonderful Structure of the Body of Fowls, in the Form of a Ship, the *Breaſt-bone* ſerving as a Keel, and their Tails, as Rudders to govern them in their *aerial Voyages*, deſerve our Attention and Admiration.



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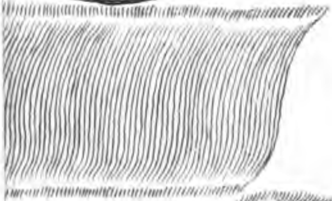

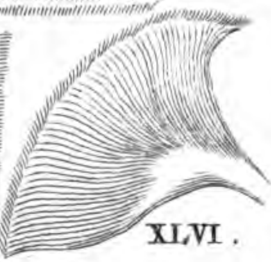
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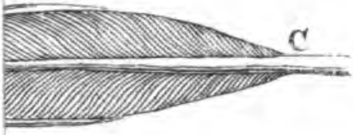

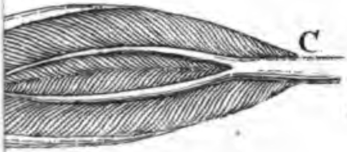

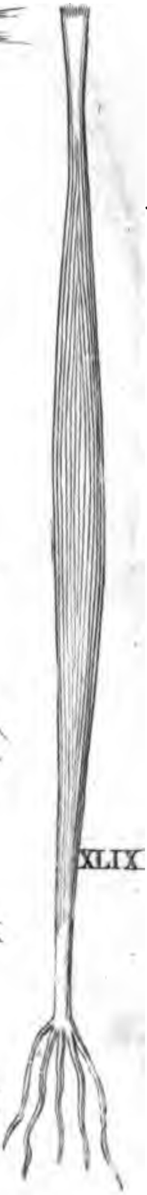
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ration. 14. The internal Make of their Bodies and the ſeveral Parts, as the *Larynx*, the *Tongue*, the inner *Ear*, the various *Muſcles*, their *Lungs*, the Poſture of the *Heart*, &c. are different for the moſt Part from other Animals. 15. The Migration of Birds is an Inſtance of great Amazement: The Stork in the Heaven knoweth מֹעֲדֶיהָ, *her appointed Times*, and the Turtle, and the Crane, and the Swallow, *obſerve the Time of their Coming*, ſaith God himſelf, *Jer.* viii. 7. What ſtrange Inſtinct ſhould induce them to change their Place? What ſhould direct ſome to warmer Climes? Others to colder Climes? Yea, what ſhould incline Swallows, for Inſtance, to take up their *Winter* Quarters in the Water, under the Ice in Lumps and Cluſters, in the frozen *northern* Seas? As 'tis well known they do. 16. The Incubation of Fowls is worth our Notice: How (ſays the great *Naturaliſt* the Reverend Mr. *Derham*) ſhould they be aware that their Eggs contain their Young? Or, that their Production is in their Power? 17. Their Nidification ought to humble the Pride of Man; with what inimitable Art, Neatneſs, and Propriety, do they contrive and build their Neſts? 18. The Egg it ſelf is a ſtupendous Contrivance of infinite Wiſdom! All Animals are produced from Eggs within, but Fowl; they exclude their Eggs, which therefore are made with hard cruſty Shells to preſerve the included Embryo from Accidents, and to contain ſuitable Nouriſhment for it; Chickens are nouriſhed by the White alone till grown great, and then feed on the ſtronger Diet of the Yolk. 19. Though all Fowl are hatched from Eggs; yet 'tis not always by the Incubation or Brooding of the parent Fowl, but by ſome other Heat or Warmth ſometimes: Thus, *Job* xxxix. (the *Oſtrich*) *leaveth her Eggs in the Earth, and warmeth them in the Duſt*; and at this Time they hatch Chickens in Ovens at *Grand Cairo* in *Egypt*; each Oven containing 80000 Eggs. 20. Some Birds feed on Grain, and are called *Granivorous*; and Birds of Prey are called *Carnivorous*, becauſe they feed on Fleſh. Theſe are a few of the many wonderful Properties of the *Nature of Birds*.

A. Indeed, *Sir*, it affords me unſpeakable Pleaſure to hear you recount the Particulars of the wonderful Nature of different Animals; and, pray, go on if you pleaſe, in the next Place, with the *Nature of Fiſhes*.

B. The remarkable Particulars in the Survey of the *Nature of Fiſhes*, which I ſhall juſt obſerve to you, are the following: 1. As they were originally made out of the Water, ſo that is the only Element in which they can live: And therefore, becauſe, 2. Their Motion is ſwimming, they need no Legs, and ſo have none. 3. Inſtead thereof, they are much better provided with Fins, and more eſpecially a proper Sort of Tails, which ſerve as Oars to waft themſelves about withal in the Water: For, 4. The Fins on the Belly principally ſerve to keep them from turning on their Backs, as being the heavier Part; as they would do were thoſe *Belly-Fins* cut off. 5. The Fiſhes uſe Reſpiration in Water, by paſſing it through their Mouths and Gills; for their Gills ſerve in them the Office of the Lungs in other Animals. 6. The Bodies of Fiſhes are contrived with ſuch divine *Geometry*, as to paſs through the denſe Medium of Water with the greateſt Eaſe, and the leaſt poſſible Reſiſtance from it. 7. How wonderouſly are they defended, beautified, and rendered more apt for gliding through the Water, by thoſe hard, ſmooth, poliſhed, numerous Scales, with which the Surface of their Bodies is ſo curiouſly overlaid? 8. The great *Author of Nature* has contrived the Eye of Fiſhes juſtly ſuitable to the Nature and Refraction of Water, different from that of Air; for their Eyes are flat outwardly, and not protuberant, leſt they ſhould wear and hinder Motion; but the *chryſtalline Humour* is made ſpherical, and not lenticular, or flattiſh, as ours, who live and ſee through Air. 9. Fiſh are contrived with an Air-bladder, which makes them buoyant; and according as they dilate or contract their Bladder, by the Means of Air, ſo they are enabled to abide higher, deſcend lower, or remain in what Part of the Waters they pleaſe. 10. Some Fiſhes are wonderfully formed with Inſtruments of Defence, Proviſion, *&c.* What amazing circular Rows of horrible Teeth fill the Mouth of a Shark? Otherſome are endued with Wings; ſome have two or more Feet, as the *Male Whale*, &c. See the wonderful *Unicorn-Fiſh* in *Fig.* LIII. whoſe Horn is 10 or 12 Feet in Length. The *Sword-Fiſh* in *Fig.* LIV. and the *Saw-Fiſh* in *Fig.* LV, are very ſurpriſing; the *Sword* and *Saw*, where they ſhoot from the Head, being 6, 8, or 10 Inches wide, and about 5 or 6 Feet in length, as I remember to have ſeen them; the Teeth of the *Saw* at the broad End being as long as ones Finger. 11. The Size of Fiſh, and other Water Animals, are almoſt infinitely different; the greateſt is the *Whale* (called *Leviathan* in Scripture) being the biggeſt of all: *Pliny*, *lib.* 9. *cap.* 3. mentions ſome *Whales* 960 Feet in length; and, *lib.* 32. *cap.* 1. he mentions *Whales* 600 Foot long, and 360 broad, which came into a River of *Arabia*. 12. The Species or Kinds of Fiſh are as various as their Size, and cannot be all known. I could, had I Time, have named to you a far greater Number of remarkable Peculiarities in the *Nature of the finny Tribe:* But, if you deſire a farther Account, you may conſult the voluminous Writings of the Learned.

A. Sir, this is abundantly better than none; and, when I read ever ſo much, I can only remember ſome Generals, ſuch as you now rehearſe; therefore pray proceed to recapitulate ſome of the chief Things obſervable next, in the *Nature of Inſects,* if you pleaſe.

B. Nothing pleaſes me more; therefore with Regard to *Inſects,* I obſerve, 1. That though they are a ſmall, and deemed a deſpicable Species of Creatures, yet when well conſidered, and carefully ſurveyed with a *Microſcope,* they will appear the Pride of Nature, wherein ſhe has beſtowed more nice and delicate Art, and diſplayed more profuſely the rich Embroidery, and elegant Beauties and Garniture of Colours, than in any of the larger Species of Animals; though unheeded and unſeen by us. 2. *Inſects* are ſo called from the Shape of their Bodies, which ſeem as it were (*inſecta.* i. e.) cut into two Parts or Halfs, and joined to one another by a ſmall String or Neck, as in *Ants, Flies,* &c. 3. They are all *Oviparous,* that is, they lay Eggs, from whence

they

they are all produced. 4. The different Kinds of *Inſects* repoſite their Eggs in different Places; ſome in *Beer*, *Vinegar*, &c. Some in *Plumbs*, *Peaſe*, *Nuts*, &c. as the *Ichneumon Flies:* In *Pears*, *Apples*, &c. as the *Phalænæ Kind:* In the *Bark*, *Wood*, *Buds*, *Leaves*, &c. of *Trees*. The *white Butterfly* lays its voracious Offspring on *Cabbage-leaves:* Some, which require warmth, lay their Eggs about the *Bodies of Animals*, as in the *Feathers* of *Birds*, the *Hair* of *Beaſts*, and even in the very *Scales* of *Fiſh:* Some go farther, and penetrate the Body it ſelf, and its Cavities, and there lay their Eggs, as in the *Noſe*, *Guts*, the *Kidneys*, the *Bladder*, the *Brain*, in the *Gall-bladder* it ſelf, and in the *Fleſh* in general. 5. Hence the ſurpriſing Production of *Maggots* and *Vermin* in all thoſe Places, and Parts of *Animals* now mentioned. 6. The *Metamorphoſis of Inſects* is a Thing extreamly aſtoniſhing; I ſhall give from Mr. *Geodart* an Inſtance thereof: See *Fig.* LVI. The *Eruca* or *Caterpillar* A, hath its Origin (*ſaith he*) from the Egg or Seed of a *Butterfly* C, called the *Peacock's Eye*; I took it the 4th Day of *May* 1635, and nouriſhed it with the Leaves of Nettles till the 11th of *June* the ſame Year; at which Time it began to prepare for its Transformation to the State in which it is called *Chryſalis* or *Aurelia* as B; in this *aurelian State* it continued changing, (with its Head downwards) 19 Days, at the End of which, there proceeded from this *Aurelia* a *Butterfly* C, with four Wings; and from its elegant Colours, called the *Peacock's Eye*, as aforeſaid. 7. *Inſects* in their firſt State, as *Maggots* and *Caterpillars*, feed on hard and coarſe Diet, as Leaves, &c. contrary to other *Animals*; in their *aurelia State*, they ſubſiſt without any Food; in their *mature State*, as *Flies*, they live on a more delicate and tender Diet, as Honey from Plants, Blood from Animals, &c. 8. It is diſcovered by the *Microſcope*, that the elegant Colours of *Butterflies*, &c. are owing to neat and well made Feathers, ſet with great Curioſity and Exactneſs in Rows and good Order. 9. The Eyes of *Inſects* are hard, fixed or immoveable; and ſome have more than two, as *Spiders* have 4, 6, or 8 Eyes: *Flies*, *Waſps*, &c. have the Cornea or outward Coat of their Eye made of curious Lattice-work, as is repreſented magnified in *Fig.* LVII. the Eyes of theſe *Inſects* have this Contrivance to ſupply the Place of the *chryſtalline*, and *vitreous Humours*, which they ('tis thought) have not. 10. The *Antennæ*, or *Feelers*, which grow from the Head of *Inſects*, ſerve them to feel out Obſtructions and Annoyances in their

Walk or Flight; are a good Guard to the Eyes and Head; and in many, a very beautiful Piece of Garniture to the Body. 11. As to the Motion of *Inſects*, ſome creep, ſome leap, ſome walk, ſome ſwim, and moſt of them fly; ſome fly with Wings, others by help of their Webs, as *Spiders*; and others by Means as yet unknown. 12. The Wings of many *Inſects* are a moſt curious Piece of Workmanſhip, diſtended and ſtrengthened with the fineſt Bones, and theſe covered with the fineſt, tranſparent, and lighteſt Membranes; ſome adorned with neat and beautiful Feathers, and many provided with the fineſt Articulations and Foldings, for the Wings to be withdrawn, and neatly laid up in their *Vaginæ* or *Caſes*; and again readily extended for Uſe. 13. Thoſe *Inſects* which have four Wings, have their Bodies thereby kept ſteady and upright in Flight; and thoſe which have but two Wings have Poiſes or Pointils, like little Balls, ſet under their Wings on each Side their Bodies for that Purpoſe. 14. The Minuteneſs, Art, and Curioſity of the Joints, Muſcles, Tendons, Nerves, &c. neceſſary to perform the Motion of the Wings, Legs, and other Parts, is a ſurpriſing Thing to all who conſider it. 15. The *Nidification* of *Inſects* far excells the moſt exquiſite humane Art, wit-neſs the nice geometrical Combs of ſome, or earthen Cells of others, or the Webs, Nets, and Caſſes woven by the admirable *Textrine Art* of ſome others. 16. Again, what ſtrange Inſtinct leads others of thoſe ſmall Creatures to make even Nature it ſelf ſubſervient to their Deſigns, by making the Vegetation of Trees, and Plants, the Means of building their little Neſts or Cells; ſuch as thoſe Caſes, Galls, and Balls, found on the Leaves and Branches of Vegetables, of many different Sorts; ſome being hard Shells, ſome tender Balls, ſome ſcaly, ſome ſmooth, ſome hairy, ſome long, round, conical, *&c.* 17. They have Parts analogous to the Brain, Stomach, Entrails, Arteries, Veins, Nerves, Lymphæducts, *&c.* yet being ſo wonderful fine and tender, are, as it were, included within the hard Caſe of their outward Body; wherewithal they are clothed and defended, as with a *Coat of Mail.* 18. Again, how curiouſly are thoſe outward Teguments, or hard Caſes of *Inſects* Bodies contrived? How are they ſet with Briſtles, ſharp Spines, *&c.* for Defence? How are they adorned with neat Imbrications, and many other Beauties, and Fineries? 19. As the Magnitude of ſome Species of Animals is very wonderful, on the contrary, the Minuteneſs of ſome *Inſects* is far more amazing: Mr. *Leuwen-*

boeck has obſerved more of theſe *Animalcules* in the *Melt* of a *Cod-Fiſh*, at one Time, than there are People living on the Face of all the Earth at once. It is alſo found, that in a drop of Pepper-water, are contained above 8280000 of thoſe ſmall Creatures; and ſome are yet diſcovered ſmaller than theſe, ſo that Millions of Millions might be contained in one Drop of Water. 20. It is the infinite Number of theſe inviſible Animals that makes ſtagnating Waters appear of ſo many different Hues, as *green*, *brown*, *reddiſh*, &c. But I cannot farther enlarge, for want of Time.

A. Well, thoſe Things loudly declare the wondrous Skill and Wiſdom of their Maker; and great pity it is they are not more attended to: But, pray, continue this pleaſing Survey next in the Nature of thoſe Creatures you call *Reptiles*.

B. In the *Reptile Species* ſeveral Things are common to other Animals, and have been already obſerved; and ſome Things are ſomewhat particular and peculiar to them, which I ſhall remark in the following Order: 1. Their ſinuous, vermicular, or creeping Motion is very curious, and contrived with the niceſt Art, and geometrial Neatneſs. 2. The whole Body of a Worm is, as it were, but a Chain of annular or ſpiral Muſcles, whoſe orbicular

Fibres by contracting render each Ring (at firſt wide and extended) more ſtraight and long; and thus the foremoſt attracting the next behind, the Action is continued through the Length of their Body, and produceth their vermicular or ſpiral Motion. 3. The *Serpent Kind* move by Means of annular Scales lying ſtraight acroſs their Bellies, contrary to what they do on the Back, and other Parts of their Bodies. Now the Edges of the foremoſt Scales lying over the Edges of the hinder from Head to Tail run out a little beyond them, ſo that when each Scale is drawn back, or ſet a little upright by its Muſcle, the outer Edge thereof (or Foot) is raiſed alſo a little from the Body, to take hold on the Earth, and ſo producing, by the ſucceſſive Action of all, the ſinuous Motion of the *Serpent*. 4. The Motion of *Snails* is performed by the undulatory Action of a long broad Skin along each Side of their Belly; and they are enabled partly by a ſlimy glutinous Matter emitted from their Body, and partly by the Preſſure of the *Atmoſphere*, to adhere firmly to all Kinds of Superficies, and in all Poſtures. 5. *Caterpillars*, while in their *vermicular State*, are curiouſly provided with little Feet, the foremoſt ſhort and hooked, to draw Leaves, &c. to them; the hindermoſt are broad

Palms, beſet around with ſmall ſharp Nails, by which they ſtick to, and graſp whatever they are upon: Whereas in their *Nympha* or *aurelia State*, they have neither Feet nor Motion, but a little in their hinder Parts; and in their *mature* or *inſect State*, they have motive Parts proper to that *Species of Animals*. 6. It is a wonderful pretty *Mechaniſm* obſervable in the Going of *Millepedes* (or *Multipedes*) that on each Side of their Bodies every Leg hath its Motion, one very regularly following the other from End to End of the Body; ſo that their Legs in going make a Kind of Undulation, and give the Body a ſwifter Progreſſion than one would imagine it ſhould have, where ſo many ſhort Feet are to take ſo many ſhort Steps. 7. The Spine or Back-bone of *Serpents* is really wonderful: How thick are they ſet with Joints, or Vertebræ? How numerous and ſtrong are their Co-operating ſmall Muſcles? By what curious Articulation of the Vertebræ can they turn and wind their Bodies any Way? 8. Some of the *Reptile Kind* are provided with a poiſonous Matter, ſerving to the more eaſy Conqueſt, and ſure Capture of their Prey; and probably may ſerve to the Digeſtion of their Food. 9. The Poiſon of the *Viper* lieth in a Bag in the Gums at the End of a certain ſharp Tooth, conveyed ed thither by a Duct from a conglomerate Gland lying in the Side of the Fore-part of the Head, by which it is ſeparated from the Blood. This Tooth is tubulated or hollow, thro' which when the *Serpent* biteth therewith, the Poiſon is conveyed to the Wound. 10. The Size, or rather Length, to which ſome of theſe *Serpents* grow is very ſurpriſing; I have ſeen the perfect Skin of a *Rattle Snake* 22 Foot long; and I was lately told, that about half a Year ſince, there was one taken on the Coaſt of *America* between 30 and 40 Foot long. 11. Thoſe Creatures of the *Serpentine Kind* are the moſt vivacious, or tenacious of Life, of all other Animals; thus we ſee Eels, Adders, *&c.* live, have Motion, yea, are very ſtrong, for a great while after they are beheaded, flea'd, and disboweled; the Reaſon of which is owing to the greater Firmity, Solidity, and Compactneſs of their Fleſh above that of other Creatures; ſo that the Action of the vital Springs, or Cauſes of Motion, continues longer in them than in other Creatures. 12. I cannot tell whence the Difference may ariſe; but Mr. *Redi* relates, that *Serpents* and *Vipers* will live not only ſome Days or Weeks, but many Months without Food, ſhut up in a Box; whereas on the contrary, a Friend of mine endeavoured ſo to keep one, but could not keep him alive above four or five Days at moſt; yet it was a large and ſound *Viper* to all Appearance. 13. Some of thoſe *Reptiles*, as *Earth-Worms*, *Snails*, &c. are *Hermaphrodites*; that is, have the genital Parts of both Sexes, the ſame *Worm* being Male and Female, ſo that they mutually copulate with each other; and the Parts of Generation are placed in the Necks of Snails, juſt under their Heads. And would you ſee more of the wonderful Nature, Kinds, and Peculiarities of the *Reptile Species*, you may be ſatisfied by reading the Natural Hiſtory of the ſeveral Parts of *Aſia*, *Africa*, and *America*.

A. Sir, I thank you; I do not know but that I may when I have Opportunity and Leiſure: But, pray, what have you to obſerve in the Nature of thoſe you call *Shell Animals?*

B. My Survey of them will be very brief; and I ſhall obſerve to you, 1. That thoſe Creatures have a Sort of middle Nature between Plants and Animals; and therefore the moſt imperfect of all the animal Creation. 2. They are therefore called *Zoophyta*, from Ζωον, *an Animal*, and Φυτον, *a Plant*; as much as to ſay, *animal Plants*, or *vegetable Animals*, becauſe they gather Food, and feed with a

Mouth like other Animals; but grow or adhere immoveably to a Shell by a Membrane, as Plants grow or adhere to the Earth by their Roots: Such are *Snails*, *Oyſters*, *Cockles*, and all the *conchilious Kind*. 3. The Shells of theſe moſt contemptible Creatures are yet made with wonderous Art, Beauty, and Finery in ſome particular Species of *Snails*, *Cockles*, &c. What artful curious Spirals, Circles, and other Divarications and diametrical Diviſions, do we obſerve therein? How are they covered to pleaſe the Fancy, and ſerve the Luxury, even of the humane Species? 4. Theſe Shells, or cruſty Houſes, ſerve the poor ſoft and boneleſs Inhabitants for Defence and Security againſt outward Accidents, from which they can ſafely retreat therein. 5. A wonderful Thing in *Snails* is, that they have their Eyes placed (not in their Heads as other Animals, but) on or at the Top of their Horns; which therefore they can move farther or nearer from their Head, and circumvolve them here and there, or one this Way, the other that, at Pleaſure. 6. The Bodies of Shell Animals are contrived without Bones, or any Thing that I know of like them; they conſiſt of a tough membranous Subſtance, analogous to Fleſh and Muſcles; but what their internal Organs of Life may be, or how they perform the vital and animal Functions, I cannot ſay; and having ſo great an Averſion to all thoſe Creatures, am prevented inquiring into it; and therefore ſhall end my Reflections on them, by giving you a Cut, ſhewing the mutual Copulation of Snails, by their Genitals G, in *Fig.* LVIII.

A. It is very wonderful indeed; as are moſt of the other Particulars which you have related of the divers Species of Animals: But, pray (before we leave this Survey of the animal Creation) let me ask your Opinion of *Griffins*, the *Phœnix*, *Dragons*, *Satyrs*, *Syrens*, *Unicorn*, *Mer-Maids*, *Fairies*, &c. Pray do you think there really are any ſuch Things in Nature?

B. The Stories of *Griffins*, the *Phœnix*, and *Satyrs*, are Fables contrived to frighten Children, or amuſe ignorant People withal. As for *Dragons*, it is certain there are or have been ſuch Creatures in foreign Countries, and pretty nearly ſuch as they are pictured. The *Dragon* is a fierce, vigilant, perſpicacious, winged and terrible Animal certainly; and therefore the Devil in *Scripture* is called the *Dragon*. I have alſo talked with thoſe who have ſeen them when young. As to the *Unicorn*, though mentioned in *ſacred Writ*, there is

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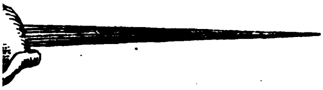

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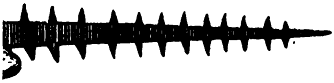

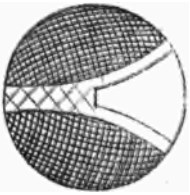

Fig: LVI.

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no ſuch Thing known on the Land, unleſs by it they meant the *Rhinoceros*, a Creature vaſtly large, with a great Horn growing out of his Noſe; others take it for a Wild-bull in thoſe Countries. The *Syrens*, were only poetical Fictions; and as to *Mer-Men*, and *Mer-Maids*, there ſeems to have been ſuch Creatures, and are ſtill in ſome remote Seas. A Perſon told me he ſaw the Hand of ſuch a Monſter carried about for a Show, it was of vaſt Dimenſions; and the Perſons who ſhowed it told him all the upper Part of the Monſter was ſhaped like a Man, having a humane Face, a Beard, *&c.* and that the Diſtance between his Eyes was twelve Inches, and all other Parts proportional: And I think he ſaid, they relate ſome Things concerning the *Female*, or *Mer-Maid*, that appeared at the ſame Time, but was not taken. The *Fairies* are nothing but a monkiſh Dream, and *Shakeſpear*'s Fancy; and pity it is, that any paſt the State of Childhood ſhould be deluded into the Belief of any ſuch ridiculous *Whims*.

A. Pray what do you reckon the Accidents common to, or attending all animal Bodies, which you mentioned as the laſt Part of our preſent Converſation?

B. They are ſuch as follow, *viz.*

Health; This ariſeth from an apt Conſtruction and due Temperament of the Parts, whereby they are capable of performing all the natural Actions, and Functions of Life.

Diſeaſe; This is that State of an animal Body, which deprives it of the Faculty of exerting every Action proper to it.

Vigilance, or the *State of being awake*; This ariſeth from the Preſence and Action of a due Quantity of animal Spirits through all the Parts of the Body; by Means of which the Organs of the external and internal Senſes, and all the Inſtruments of Motion depending on the Will, are properly affected by external Objects, and eaſily perform all their Actions and Motions.

Sleep; The State contrary to *Vigilance*; but what is the Cauſe, or wherein it doth conſiſt, the greateſt *Phyſiologiſts* differ in their Determinations, and are puzzled to account for it.

Dream; This is an Action of the reflective Faculty of the Mind, which is always active even in Sleep, and doth therein recollect and review the Ideas which were preſent to it when the Body was waking:

But the Body aſleep not admitting the Exerciſe of the rational Faculty of the Mind, it rangeth thoſe Ideas for the moſt Part in a confuſed, unnatural, and imperfect Manner; and this Viſion of Things we call a *Dream.*

Hunger; This is that Quality which ariſeth from a Vellication of the inner Coats of the Stomach, by the Action of the digeſting Juice; which having no Food whereon to ſpend its Force, gnaws on the Stomach it ſelf, and thereby excites in our Minds the Deſire or Appetite of Food.

Thirſt; This is ſomewhat analogous to *Hunger*; for a due Quantity of Moiſture being wanting in the Stomach, and Parts of the Throat and Mouth, produceth that moleſting Senſation which creates in us a Neceſſity of Drinking.

Death; This brings an Animal to its laſt State; and is nothing but a final Obſtruction or natural Ceſſation of all the animal and vital Faculties and Functions of the Body; which then remains in a State of perfect Quieſcence, and is entirely paſſive to all other Changes and Conditions it meets withal in this World. And, as Death puts an end to all Things, ſo I judge it moſt natural to end this long Reflection on the wonderful Works of God, the great Author of Nature, with the awful Subject of Death; which alſo e'er long will intercept all ſuch delightful and agreeable Converſe between you and me, as hath hitherto paſſed between us.

A. Ah! Were it not for the Proſpect of a better, and a more perfect State of Life and Being hereafter, How dreadful would be the Thought of parting with our dear friendly and agreeable Company and Acquaintance, even in this Life of Troubles! I am heartily ſorry that our Knowledge extends no farther in the Nature of Things; ſince it is a Topick, which of all others, gives me the moſt ſerious and perfect Pleaſure in the Contemplation thereof. And, ſince you have taken abundant Pains to repleniſh my Mind with the beſt Treaſure of this Sort of Science; I can but love you, and return you my ample Thanks for the ſame.

FINIS.

A
PARAPHRASE
ON THE
CXLVIIIth PSALM, by the Earl of *Roſcommon*; exhorting to praiſe the ALMIGHTY, and All-wiſe CREATOR of the UNIVERSE.

O Azure Vaults! O Chryſtal Sky!
The World's tranſparent Canopy,
Break your long Silence, and let Mortals know
With what Contempt you look on Things below.

Wing'd Squadrons of the God of War,
Who conquer whereſoe'er you are,
Let ecchoing Anthems make his Praiſes known,
On Earth his Foot-ſtool, as in Heav'n his Throne.

Great Eye of all, whoſe glorious Ray
Rules the bright Empire of the Day,
O praiſe his Name, without whoſe purer Light
Thou had'ſt been hid in an Abyſs of Night.

Ye Moon and Planets, who diſpenſe
By God's Command your Influence,
Reſign to him, as your Creator, due,
That Veneration which Men pay to you.

Faireſt as well as firſt of Things,
From whom all Joy, all Beauty ſprings,
O praiſe th' Almighty Ruler of the Globe,
Who uſeth Thee for his imperial Robe.

Praiſe him ye loud harmonious Spheres,
Whoſe ſacred Stamp all Nature bears,
Who did all Forms from the rude Chaos draw,
And whoſe Command is th' univerſal Law.

Ye watry Mountains of the Sky,
And you ſo far above our Eye,
Vaſt ever-moving Orbs, exalt his Name,
Who gave its Being to your glorious Frame.

Ye Dragons, whoſe contagious Breath
Peoples the dark Retreats of Death,
Change your fierce Hiſſing into joyful Song,
And praiſe your Maker with your forked Tongue.

Praiſe him ye Monſters of the Deep,
That in the Sea's vaſt Boſom ſleep,
At whoſe Command the foaming Billows roar,
Yet know their Limits, tremble and adore.

Ye Miſts and Vapours, Hail and Snow,
And you, who thro' the Concave blow,
Swift Executors of his holy Word,
Whirlwinds and Tempeſts, praiſe the Almighty Lord.

Mountains, who, to your Maker's View,
Seem leſs than Mole-hills do to you,
Remember how, when firſt Jehovah *ſpoke,*
All Heav'n was Fire, and Sinai *hid in Smoke.*

Praiſe him ſweet Offspring of the Ground,
With heav'nly Nectar yearly crown'd,
And ye tall Cedars celebrate his Praiſe,
That in his Temples ſacred Altars raiſe.

Idle Muſicians of the Spring,
Whoſe only Care's to love and ſing,
Fly thro' the World, and let your trembling Throat
Praiſe your Creator, with the ſweeteſt Note.

Praiſe him ye ſalvage, furious Beaſt,
That on his Stores do daily feaſt,
And you tame Slaves of the laborious Plow,
Your weary Knees to your Creator bow.

Majeſtick Monarchs, Mortal Gods,
Whoſe Pow'r hath here no Periods,
May all Attempts againſt your Crown be vain,
But ſtill remember by whoſe Pow'r you reign.

Let the wide World his Praiſes ſing,
Where Tagus *and* Euphrates *ſpring,*
And from the Danube's *froſty Banks to thoſe,*
Where, from an unknown Head, great Nilus *flows.*

You that diſpoſe of all our Lives,
Praiſe him from whom your Pow'r derives,
Be true and juſt like him, and fear his Word,
As much as Malefactors do your Sword.

Praiſe him Old Monuments of Time,
O praiſe him in your youthful Prime;
Praiſe him fair Idols of our greedy Senſe,
Exalt his Name, ſweet Age of Innocence.

Jehovah's *Name ſhall only laſt,*
When Heaven, Earth, and all is paſt:
Nothing, Great God, is to be found in thee
But unconceivable Eternity.

Exalt, O Albion's *favour'd Race,*
The God of Gods, the God of Grace,
Who will above the Stars your Empire raiſe,
And with his Glory recompenſe your Praiſe.

A N

ALPHABETICAL, ORTHOGRAPHICAL, and ORTHOEPICAL

INDEX;

WHEREIN

All the philoſophical Words and Terms of Art, contained in the foregoing Treatiſe, are duly accented in Order to their true Pronunciation, and referr'd to the Pages wherein they are explain'd.

The Uſe of this *Index* may be thus eaſily underſtood, by obſerving theſe two Things. *Firſt*, That the ſingle Accent (') denotes the Emphaſis, or Streſs of the Voice, which is to be laid on that Syllable of a Word over which it is ſet; as in the Word *An'timony*, the Syllable (*An'*) is pronounc'd ſtronger than the reſt. *Secondly*, The double Accent ('') denotes the following Conſonant is ſounded twice, or doubly, though wrote ſingle; as the Word *A''nimal*, is to be ſounded *Annimal*; and *Bi''tumen*, is ſounded *Bittumen*; and ſo of any other.

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